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PRINCIPLES OF TAXATION.

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II.—THE PLACE OF TAXATION IN LITERATURE AND HISTORY.
PART V.

TAXATION IN EGYPT.—Herodotus, the Father of History, in writing more than two thousand years ago about Egypt, characterized it as a land of wonders, "containing more marvelous things than any other country," and in this opinion the judgment of succeeding ages, finding an all-sufficient warrant in primeval, stupendous, and mysterious monuments, has been compelled, as it were, fully to acquiesce. At this latter day, however, there has been added to Egyptian history what may be rightfully termed another wonder, namely, the most interesting and instructive experience in taxation in the world's history. Interesting and instructive because it affords the most striking and unprecedented illustrations of the results contingent on an arbitrary and unintelligent treatment of a heavy annual requirement of revenue for the support of a state, as contrasted with the results which have been the sequence of a wise and practical policy for a like purpose in the same country and under similar conditions.

Previous to the military occupation of Egypt by the British forces in 1882, consequent upon the suppression of the rebellion under the lead of Arabi Pasha, the condition of the country was wretched almost beyond conception. Its revenue system, in accordance with Asiatic ideas, comprehended nearly every form of iniquitous extortion. The principal source of revenue was essentially in the nature of a land tax; and for the dusky fellah, who represents the bulk of the Egyptian population, and who with a

grimy white shirt girded about his loins, plows, sows, and reaps to-day as his forefathers have done before him for thousands and thousands of years, this tax meant that his houses, his cattle, and his lands "were but so much food placed before the lips of our lord (the Khedive) that he might eat thereof and have his fill."

"The seed was often barely sown for the coming crop before the tax-gatherer appeared with the usurer as his familiar spirit at his heels, claiming not only heavy tithes of the treasury, but the many tithes of those tithes which never reached the treasury, waylaid on the road along the steep ascending gradients of a predatory hierarchy. For what purposes or to what amount he could be mulcted the fellah had no means of knowing. The only record he kept was the number of strokes from the *koorbash* which had wrung from him his last piastre. The only certainty he acquired by long and bitter experience was that, let his harvest be good or bad, only so much would be left to him as would barely suffice to keep body and soul together. Every year brought fresh imposts, and every new tax became in the hands of a corrupt administration a fresh pretext for unlawful exactions. To satisfy them the land was made to yield more frequent and more valuable but also more exhausting crops, until the soil itself caught the contagion of universal impoverishment. Still the arrears of taxation grew, and with them arrears of private indebtedness," until at last whole villages not infrequently petitioned the pasha "to accept the fee simple of their lands on condition merely that they should be allowed to rent them from him at an annual rental greater than the land tax itself, but still vastly less than the total amount of illegitimate imposts grafted on to the land tax."

Extortion for the purpose of obtaining revenue for the state, and plunder for the officials intrusted with its collection, was not the only form of oppression to which the miserable Egyptian peasantry were subjected. By an ancient Asiatic institution called the *corvée*, the fellah was liable at any moment to be seized and dragged perhaps off to some distant part of the country to work under constant dread of the taskmaster's whip at any task suggested by the caprice of the Khedive or some powerful pasha; and it was under this system of compulsory, unpaid, severe, unfed labor, and with great attendant sacrifice of the lives of his subjects, that the then Khedive, Ismail Pasha, mainly built the Suez Canal. In addition there was a system of "military conscription invested with the terrors of the press-gang; there was the water supply for irrigation, generally inadequate and often dependent upon the caprice of some local magistrate or corrupt official; there was the greed of unjust judges; there was the whole hungry bureaucracy, feeding upon those beneath it in order that it might in turn feed those above it."

Such, then, was the life that the fellah "lived in the days of the oppression"; not in the dim twilight of the past, but less than twenty years ago; not in remotely hidden corners of Egypt, but throughout its entire length and breadth.

In 1879 the exactions in Egypt, nominally for revenue, had become so oppressive, that the population refused to pay them, and, rising in revolt, drove Ismail Pasha from power and installed his son, Mohammed Tewfik, in his place. The new pasha found the finances of the country in such confusion, that he was obliged to invoke the aid of European Governments in order to obtain the means necessary to pay the interest on the public debt; and in this way the British and French Governments, as representing a large majority of the creditors, or holders of the debt, were practically given control of all the Egyptian sources of revenue. This condition of affairs was, however, in turn so repugnant to the people that in the spring of 1882 a revolt broke out, headed by Arabi Pasha, the then Minister of War, which, with a popular cry of "Egypt for Egyptians!" seemed for a time likely to be successful. But with the utter defeat of Arabi at the battle of Tel-el-Kebir, in September, 1882, the rebellion collapsed; Tewfik Pasha was restored to power, while the British forces, for the purpose mainly of maintaining the situation and insuring peace, practically retained possession of the country. It was under such circumstances that a reconstruction of the antiquated, arbitrary, and unequal Egyptian system of collecting revenue was entered upon as an immediate and imperative necessity for the establishment of a new and better national fiscal policy, and the attainment thereby of some degree of national prosperity.*

The career of Ismail Pasha, who as Khedive ruled over Egypt from 1863 to 1879, was a remarkable one. He was "as fine a type of the spendthrift as can well be found, whether in history or fiction. No equally reckless prodigal ever possessed equally unlimited control of equally vast resources. He came to the throne at a moment when there seemed to be no limit to the potential wealth of Egypt. The whole land was his to do what he liked with it. All the world was ready to lend money to develop it." The results of his government may be rightfully characterized from

* Notwithstanding the adverse criticism that has been made on the action and policy of Great Britain, under the then existing circumstances, subsequent experience has proved that it saved Egypt from barbarism and anarchy, and all the nations interested in that country "from incalculable losses in blood and treasure, to say nothing of the deep dishonor which these losses, foreseen and yet unhindered, would have brought on civilized mankind. The Arabist movement possessed great destructive force, but it had not within itself the elements necessary for the construction of anything enduring."—(*England in Egypt, Sir Alfred Milner.*)

almost every point of view as appalling. When he commenced to rule in 1863 "the debt of Egypt was a little over three million pounds sterling ($15,000,000). The annual revenue of the country was amply sufficient to meet all needful expenditure. Yet at the end of 1876 the debt had risen to £89,000,000 ($445,000,000). A country of six million inhabitants and only five million acres of cultivated land had added to its burdens at the rate of £7,000,000 ($35,000,000) a year. At the same time the taxation of land had been increased by something like fifty per cent. There is nothing in the fiscal history of any country, from the remotest ages to the present time, equal to this carnival of extravagance and oppression." (England in Egypt, by Sir Alfred Milner, late Under-Secretary for Finance in Egypt. London, 1894.)

The revenue annually collected under Ismail Pasha is probably not accurately known, and has been reported as high as £15,000,000 ($75,000,000) from an estimated population in 1872 of 5,203,000. But, whatever the amount, it is certain that a very considerable portion of what was wrung from the miserable peasantry, never found its way into any official ledger, or reached the national treasury. Of a great loan of £32,000,000 effected by the Khedive in 1873, only £20,700,000 reached the Egyptian treasury. The total amount sunk by the Government in the Suez Canal is estimated at £16,075,000 ($80,375,000). Yet Egypt has no share in the vast profits of the undertaking. It was not, however, the amount of taxation, crushing as it was in many cases, which worked the greatest mischief. "It was, above all, the cruel and arbitrary manner in which the taxes were collected. The fellah was seldom sure of the amount that would be demanded of him. He was never sure of the moment when the demand would be made. The moment might, as likely as not, be the very one in which he was least able to pay. Called upon to find ready money while his crops were still in the ground, he was simply driven into the arms of the money-lender. His choice lay between so many blows of the *koorbash* and the acceptance of the usurer's terms, however onerous. Under these circumstances money was borrowed at as much as sixty per cent per annum. Worse than that, it was often obtained by the sale of the growing crops, which were estimated for the purpose of the advance at half or less than half their value. This state of things was bad enough, and it was pretty general, but the ruin of the cultivator was consummated in many instances by positive collusion with the usurer on the hint of corrupt officials. The latter would demand the payment of taxes by the peasant, who was already in debt, at the very time when the interest on his debt was due. If he had any cash at all the authorities were bound to get it. When the usurer came after them, there was nothing left to the fellah but to surrender his land and

cattle, or renew his bond on still more ruinous terms. He was, in fact, entirely at the mercy of the lender."

That some betterment of such a condition of affairs was imperative if civilization was to be maintained and the substantial dissolution of Egyptian society prevented, seemed evident, and to effect it most rationally and speedily, an experiment was instituted that, as respects its nature and results, finds no parallel in the world's history. This in brief was the creation of a fiscal commission, by Sir Evelyn Baring, then British agent and consul general in Egypt (but now Lord Cromer, minister plenipotentiary), the members of which were selected solely by reason of their recognized qualifications for the work in hand and invested with almost autocratic powers. To this commission was intrusted the task of examining and reconstructing a revenue system of long duration and fortified by the precedents, customs, and prejudices, of an entire country, with a not inconsiderable population. The commission when organized in 1884–'85 entered upon its work under exceedingly unfavorable circumstances. The financial pressure was most acute. The magnitude of the national debt was apparently overwhelming; and the prices of the leading agricultural staples of the country, depressed in an extraordinary degree by world-wide competition, consequent upon improved conditions of production and transportation, seemed to preclude all possibility of obtaining any increased revenues from the masses by a continuance of the old, or even by any new methods of extortion. The first step taken was to abolish as rapidly and as far as possible all unnecessary and unproductive expenditures; and for this there was large opportunity. A diminution was made in the pension list, and in the number of superfluous and highly paid officials. By the concurrent action of the great powers of Europe the rate of interest on the funded debt of Egypt was also somewhat reduced.

The next important measure that claimed the attention of the commission was the grievance of the *corvée*, or system of enforced labor on the part of the peasantry on the public works; which, if entitled to be called taxation, was taxation of the worst and most wasteful kind, entailing sacrifices upon the people out of all proportion to the money which it saved to the state. It was not, however, found practical at the outset to abolish it altogether. The old practice by which the fellahs might be dragged away from their villages at any moment for any purpose, public or private, upon which the Khedive might choose to employ them, was at once totally abrogated. On the other hand, the agriculture of Egypt, the main source of support of her people, depends upon the water of the Nile, distributed through irrigating ditches or canals; and in order that these should fulfill their purpose, it is

necessary to keep them clear of the mud which the Nile at the period of its annual overflow brings down in large quantities; and to effect this, no other labor than that of the fellahs' is available. Finding that this indispensable work could be done by contract and paid labor, for about £400,000 ($2,000,000) per annum, the commission appropriated, from the funds made available from loans and the reduced expenses of the Government, the sum of £250,000, to be paid annually as compensation for such service, and thereby at once reduced by more than fifty per cent the number of men formerly called out and compelled to perform service; without payment. In addition, the employment of skilled engineers and the introduction of improved machinery for dredging and excavating, still further reduced both the necessity for the labor of individuals and the general aggregate of former expenditures. Whatever of the obligation of the *corvée* is still incumbent on the fellah, as, for example, when he is called in any sudden emergency to prevent breaks in embankments in time of flood, or keep clear the irrigation of his own land, is therefore largely in his own interest, and even this will probably at no distant day be abolished. But, be this as it may, it is certain that what of the *corvée* the commission has felt compelled to retain does not represent one tithe of the awful incubus which the old *corvée* represented "in the days of the oppression." The use of the *koorbash*, or lash, which was the former invariable accompaniment of unpaid labor in Egypt, has also been absolutely prohibited. Of other forms of relief to the people of Egypt, effected by the English fiscal commission, the following may be mentioned:

An abandonment of a tax on sheep, goats, and camels, which was very obnoxious to the agriculturists; a tax on weighing and measuring; *octroi* taxes on rice, oil, and other commodities; and a tax on all trades and crafts, in the nature of licenses on business and professions, which was collected in innumerable small sums from the poorest of the people. The price of salt, the supply and sale of which was a monopoly of the state, has been reduced to the extent of forty per cent, while large abatements have been made in judicial fees, postal and telegraph rates, and in railway rates and fares.

As formerly, the tax on land is yet the corner stone of Egyptian finance, and can not be rapidly or radically disturbed; but large measures of relief have nevertheless been instituted. A vexatious diversity of rates at which land has been assessed in different parts of the country has been simplified to the extent that a former total number of fourteen hundred different rates has been brought down to two hundred. The value of land varies greatly, according to its proximity to the Nile, and the extent to which it can be profitably supplied with water for irrigating pur-

poses—land devoted to growing rice crops requiring constant watering, but which must never be inundated. "From time immemorial Egyptian law has recognized an intimate connection between the land tax and water supply. The land which, in any given year, gets no water, is for that year legally exempt from all taxation whatever. As soon as it gets water its liability is established. But it is evident that the mere fact of receiving some water, though it may set up the liability of the cultivator to pay, does not insure his capacity to do so. In order to insure that, he must get his water in proper quantities, and at the proper times. But this is just what, in thousands of instances, he could not get, as long as the irrigation system remained in the state of unutterable neglect and confusion into which it had fallen in the period previous to the British occupation of the country." Arrears of land taxes throughout the whole country to the amount of about $5,000,000 have been remitted altogether by the commission, while lands incapable of cultivation, but heretofore made subject to taxation, have to a great extent been relieved.*

The area of land under cultivation in Egypt in 1894 was about five millions of acres; and in the least prosperous part of the country the tax on the same has been reduced, since the creation of the commission, to an extent of at least thirty per cent. The revenue from the taxation of land, which is at present estimated as not exceeding on an average £1 ($5) per acre, constitutes fully one half of the total receipts of the Egyptian treasury.

In 1886, before the reduction in this tax had been made,

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* "A considerable class of lands, called *mazroof*, sold many years ago by the Government at a quitrent which in the course of time had come to be looked upon as a specially high rate of land tax, has also been assimilated to the surrounding districts.

"Another measure of great importance for the future has been the adoption of more liberal fiscal regulations with regard to land brought for the first time under cultivation. Formerly the first attempt to reclaim a piece of uncultivated land brought down the tax-gatherer, who at once subjected it to the full burden of the land tax. Now it remains untaxed until it yields the first remunerative crop, and then for two years it pays only half the normal rate. In the same broad spirit, facilities have been granted to people who are found without proper title in possession of land belonging to the Government, but on which they have spent labor and money in developing. Such occupiers can nowadays be confirmed in possession on very easy terms, in which full account is taken of all improvements. Finally, a scheme has been devised, and has been already applied with considerable success, for securing relief, without having to enter upon a general reassessment, in those no longer very numerous cases where the existing land tax is really excessive. Instead of allowing, as hitherto, arrears to accumulate which have ultimately to be remitted, the defaulting land is seized and put up for sale, but on such terms as to facilitate the re-entry of the owner on a lighter rating wherever the arrears are shown to be due to a prohibitive assessment in the past.

"Thus, not only the huge accumulation of arrears and the many smaller obstacles have been removed which blocked the approaches to the land tax, but the land tax itself has been cleared of its most mischievous excrescences."

its revenue product was £5,116,000 ($25,580,000—the Egyptian pound being about £1 0*s.* 6*d.*). In 1891 its product, after the large reductions noted, was £5,098,000 ($25,490,000); a result constituting a new and striking illustration of a little regarded principle of taxation, that low or moderate taxes are as a rule more prolific of revenue than comparatively high taxes. It is also worthy of note that the land taxes of Egypt under the reduced rates are collected with greater facility and much less expense than under the old system.

Viewed, as it should be, rather as a rent than as a tax, the present Egyptian tax on land can hardly be regarded as oppressive. The number of land proprietors in Egypt, according to the revenue returns for 1893, was 1,025,000. In only 8,569 cases were the fiscal officers obliged to seize crops in payment of the land tax. In three out of four of such cases the mere seizure acted as a sufficient threat to induce payment, and in only 2,158 cases was it necessary actually to sell the defaulters' crops. As for the seizure and forced sale of the land itself, there were only 1,865 cases of seizure and less than one in nine of actual sale—viz., 204. The number of expropriations for failure to pay the land tax had therefore been reduced to the infinitesimal proportion of one in five thousand.

The total revenue receipts of the Egyptian treasury during the year 1886, after the commission had begun to exert an influence on the fiscal affairs of the country, was £7,337,000. In 1890 they had increased to £8,040,000, and in 1891 to £8,366,000 ($41,830,000). To the extent of about one third, this augmentation was due to heavier taxes on tobacco, and a few new taxes, as a tax on house occupancy, from which all foreigners previous to 1887 were exempt. In general, the increase in revenue receipts consequent upon new taxes imposed since 1885 has been about £570,000; but the reductions of taxation have at the same time been notably in excess of this amount. The public debt of Egypt, which was nearly £99,000,000 in 1880, has been increased in recent years to the extent of between two and three millions; but this increase has been mainly devoted to the redemption of pensions and to reproductive public works.

The general results that have been attained in Egypt under the fiscal and administrative policy of the British commission are, therefore, worthy at least of being characterized as extraordinary. They can not, moreover, be properly exemplified by any mere exhibit of figures. The benefit that has accrued to the Egyptian people can not be properly measured by a reduction of their taxes, but rather by the increase in their means of bearing the burden that remains. "The greatest vice of all in their old system of government was that, while the demands made upon

the people were constantly increasing, their capacity to meet those demands were being steadily impaired. The Government took from them twice as much as it was entitled to take, and did not give them in return what it was bound to give; while the coffers of the state and the pockets of its servants were being filled by the plunderer of the peasantry. The soil was deteriorating from the neglect of those great public works upon which its fertility depended."

All this abuse has now been entirely abrogated. For the first time since the days of the Roman administration, order and prosperity reign in the valley of the Nile.

At no previous period since Egypt began to have a name has the fellah lived under a government so careful to protect his rights. For the first time he is allowed to control the fruits of his labor. To-day, under British domination, every Egyptian peasant knows exactly the amount of taxes he has to pay, and when he has to pay them; and that when he has once paid the legal amount, no official, big or small, has the power to extort from him one single piaster beyond it.* He knows, too, that he can not at any moment be seized and dragged off as formerly, perhaps to some different part of the country, to work under constant dread of the whip, at any task suggested by the caprice of the Khedive or of some powerful pasha. Under such circumstances Egypt has never, certainly not within a recent period, enjoyed so large a measure of prosperity. Notwithstanding the recent universal decline in price of agricultural staples, the Egyptian products and exports of cotton, sugar, tobacco, wheat, etc., have rapidly increased, and at present are much greater than at any former period. The annual increase in the great staple product of Egyptian agriculture —cotton—from the average of 1884–'89 to that of 1893–'94 was nearly a hundred per cent, whereby the cultivator was not only able to pay his taxes more easily, but has more money left for his own needs.

When England first occupied the country the four-per-cent Egyptian debt securities were quoted at about 50, and not long before had been quoted as low as 27. To-day their quotation is over 100, with a reduction of their originally stipulated interest.

One of the most recent results of the British occupation of

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* "The poorest peasant in the country is now annually furnished with a tax-paper, *wird*, as it is called, which shows him exactly what he has to pay to the Government, and at what seasons the installments are due. The dates of these installments, moreover, which vary in different provinces, have been arranged so as to correspond as nearly as possible with the seasons when the cultivator realizes his produce, and is therefore in the best position to discharge his debt to the state. The necessity no longer exists of resorting to bribery as a protection against the extortion of sums not due on the part of the tax-gatherer."

Egypt has been a practical abolition of human slavery. Under existing regulations every slave in Egypt (the former great market for enslaved people of Africa) may demand his manumission if he chooses; and if the Soudan be retaken by Egyptian troops under British leadership, it will be equivalent to opening the prison doors to hundreds of thousands of captives.

In 1876 the district known as the "Fayoum," on the west side of the Nile, southwest of Cairo, was, according to a correspondent of the London Times, "reduced by misrule to the greatest depths of misery ever probably experienced in modern times in Egypt. The burden of taxation and oppression had produced an amount of want which almost bordered on starvation. At the present time (1894) it is one of the most prosperous and contented of provinces, and bids fair to become in the future the very garden of Egypt."

A further striking proof of the prosperity of Egypt under British administration is afforded by the financial report for 1895, made by Lord Cromer, the British diplomatic agent, which shows a revenue in excess of all expenditures for that year of £1,088,000 ($5,440,000).

That the continued prosperity and development of Egypt are dependent on the continued administration of the country by the British Government seems too clear to admit of questioning; and it is also not less evident that if Egypt should now be abandoned by it, all that has been done for it would be speedily undone.*

Finally, in considering the recent and remarkable fiscal experience of Egypt, one point of great economic interest should not be overlooked—namely, the lesson it teaches of the closeness of the relations of the finances of a state to the welfare of its people; and that these relations, which are apt to be obscured, or even wholly lost sight of, under conditions of high and complex civilization, speedily make themselves apparent, and are therefore more easily traced and studied in a country of limited area and simple conditions of living on the part of its people. This experience historically groups itself under three separate and distinct periods: *First*, the period of reckless prodigality under the reign of Ismail Pasha, from 1863 to 1879, of sixteen years. *Second*, a period of sudden retribution fraught with widespread misery, from 1879

* In a recent debate (1896) in the British House of Commons, Mr. Chamberlain, the Secretary of State for the Colonial Department, said: "It would be impossible to pass judgment upon the policy of the Government unless the Government first made up its mind definitely in regard to the immediate evacuation of Egypt. Nothing in recent history could be looked back to with more pride and satisfaction than the peaceful revolution in Egyptian affairs which had been accomplished with a handful of men and a British civil administration. If Egypt should be abandoned, all this would be undone. Egypt must be defended if her prosperity was to continue."

to 1886. *Third*, a period of recovery from utter collapse, from 1886 to the present time, the result of intelligent fiscal administration so signal and complete as to be without precedent in history. It remains to be seen what will happen in the future in the event of the withdrawal of British occupation and governmental administration of the country in compliance with the wishes of all the other great powers of Europe.

An illustration of how history in Egypt has seemingly repeated itself in respect to taxation is here pertinent to the subject. Prior to the nineteenth century a key to the hieroglyphic writing of Egypt or of the so-called "demotic," which was a shorthand or abridged form of the true hieroglyphics, had not been discovered, and there was little probability that it ever would be.

In 1799, however, during the French occupation of Egypt, a large slab of black granite (now in the British Museum), which originally had been a monument in some public edifice, was discovered in excavating for military purposes near the village of Rosetta, a place in Lower Egypt not far distant from Alexandria and the western mouth of the Nile. The slab had on it three inscriptions—the first in hieroglyphic text, the second in the demotic character, and the third in Greek letters; and a study and comparison of them, mainly by Champollion, a French scholar, led to a solution of the problem of deciphering the hieroglyphic writing, which previously had almost completely baffled analysis. It was then found that the trilingual inscriptions were in the main a copy of a decree in honor of Ptolemy V, Epiphines, King of Egypt, who, about 193 B. C., had conferred great benefit on his country and its people by remitting certain taxes and reducing others, and read as follows:

> Considering that the King Ptolemy, ever living, the well-beloved of Phtah, most gracious son of the King Ptolemy and of the Queen Arsinoë—gods philopatores (father-loving)—has done all kinds of good; . . . that he has not neglected any of the means within his power to perform acts of humanity; that in order that in his kingdom the people and in general all the citizens should be in prosperity, he has suppressed altogether some of the taxes and imposts established in Egypt, and has diminished the onus of others: . . , It has therefore pleased the priests of all the temples of the land to decree that all the honors belonging to the king shall be considerably augmented; that his statue shall be erected in the most conspicuous spot in each temple; that the priests shall perform three times each day religious service to these statues; and that in all great solemnities all the honors due to other deities shall be paid them. . . .

More than two thousand years have elapsed since the service rendered by Ptolemy to Egypt and its people by the remission and readjustment of taxes was thus commemorated. King,

priests, and people have long since passed away; but if they could return, their gratitude to the English tax commission for the service rendered to their country and to their descendants would certainly again be recognized and fitly commemorated.

Another point of historical and fiscal interest in connection with Egypt is worthy of notice. Of the conquest and occupation of Egypt by the French, 1798–1801, the masses of its people have but little knowledge; but the name of General Kléber, to whom the government of the country was intrusted by Napoleon on his return to France, is still held in grateful remembrance, coupled with the highest title that the Arabs could bestow upon him—namely, "The Just"—because under his rule, as popular expression has it, "he levied taxes only once."*

TAXATION IN BRAZIL.—A most striking and instructive example of the strangulation of the commerce of a country, and its consequent impoverishment by reason of a vicious system for the collection of revenues, is to be found in the recent experience of the South American state of Brazil. Its Government derives its support mainly from export and import duties, and every province, whether maritime or interior, collects a separate duty of generally about four or five per cent on its exports, to which in some instances a municipal tax is added. There is no taxation upon either real or personal property; but when a piece of real estate is sold, the purchaser is required to pay a fee to the Government of five per cent on the selling price. All stores are obliged to obtain a license, for which a fee is exacted, the amount varying with the kind of trade. The duties on imports are extremely heavy, and on many articles, especially foods, are in excess of their original cost at their place of production. On some of the principal articles of export the duties have been as high as twenty-three per cent *ad valorem*, on rubber and cocoa fourteen per cent, and thirteen per cent on coffee. Few countries have greater commercial and industrial possibilities than Brazil; but Nature's prodigal efforts have been rendered futile by a vicious system of taxation, which has so restricted the development of her resources that the increase of exports in recent years has been mainly confined to the single article of India rubber, for the supply of which the country has practically a monopoly. What is raised in Brazil is taxed;

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* For the material which has furnished the basis for the foregoing narrative of the recent fiscal (tax) experience of Egypt, the writer has been mainly indebted to a book, England in Egypt, London, 1894, by Sir Alfred Milner, formerly a member of the Egyptian Fiscal Commission, and now chairman of the British Board of Inland Revenue; to a series of letters published in the London Times in 1894; to various official documents, and interviews with those personally conversant with the subject under consideration.

what is bought by her is taxed; while taxes are levied on her product of labor and on the payments for such products. The general result, therefore, has been that the world can buy comparatively little of the Brazilian, and the Brazilian has comparatively little with which to buy of the world.

HOW THE GREAT LAKES WERE BUILT.

By J. W. SPENCER, Ph. D., F. G. S.

THE framing of the continent was a work of great antiquity Upon that foundation the plains and mountains were slowly built, and out of them the valleys have since been carved. The last touch in the completion of the continent has been the making of the lakes. The work is geologically new, and the knowledge of how the lakes were produced is only a few years old—or about a decade and a half since the students have been seriously attempting to disentangle the complex history of the lakes, and from the maze of disorderly speculation to bring together an orderly assemblage of scattered facts and events. To have partially accomplished this effort, it required tedious waiting for the discovery of connecting links which were not always obtained in their logical order; and it was often necessary to learn how to look for them, and so the footsteps had to be retraced many times before the lost trails were recovered. Many new things have been learned in studying the history of the lakes, but the most striking physical changes have been during the period immediately preceding and reaching into modern times.

High Continental Altitude of Former Times.—In very ancient times the lake district formed a great plateau at a considerable altitude above the sea, with some bordering mountains or high lands. Those ancient plains have since been molded into rolling hills and broad valleys, and the mountains have been worn down to almost plains themselves. When mountain ridges are close upon the sea or adjacent low plains, at so slight an elevation that the streams are all sluggish, then, aided by chemical action, the rains and streams are always washing down the elevated lands, first making ravines and valleys, and then enlarging them into broad plains with low hills, for the level has been reached below which the agents of destruction can scarcely affect the slightly elevated lands, as is illustrated in Figs. 1 and 2.

If the plains were always to remain at low altitudes, increasing slightly in elevation in proceeding landward, above the drainage basins, and with the high lands gone or going, the country would become monotonous without any bold reliefs or the possi-

bility of the formation of any deep valleys. While such finished conditions may often occur over large districts, yet such is not the character of very great regions, as Nature seldom allows the completion of these processes, for with the wearing down of one area another quarter is elevated by internal forces, until new plateaus rise in bold relief. The rains gather into streams and cut out gorges and valleys with their forms depending upon the character of the rocks and the length of time that the erosion is in progress. The gorges and valleys grow in length, like the Niagara cañon, until the slopes of the streams become so gentle that they can not deepen their channels any more. After that stage, the only work of the river is to carry away the rocks dissolved or washed from the sides of the valleys, which are thus widened into broad flats, and in their later stages great plains. Such a formation of base planes of erosion is illustrated in Fig. 2.

FIG. 1.—SECTION SHOWING A HILLSIDE (*d c*) BEING WASHED DOWN TO THE BASE PLANE OF EROSION (*c b*), WHICH IS ITSELF ALMOST REDUCED TO SEA LEVEL.

Applying this process of denudation to the lake region, it becomes evident that the land must have stood high enough above the sea for the rivers to remove the *débris* washed into them by the millions of little streams —that is to say, the continent was sufficiently high for the excavation of the deepest valleys now beneath the lake waters. As the sea was very distant from the lakes, much farther than now, and the upper lake basins were still farther inland, the altitude of the continent must have been even greater than the depth of the deepest lake basin below the sea level. On the other hand, the slope of the land must have been gentle, with the elevation just high enough to allow the drainage of the valleys, without the production of cañons through them, and to enable the streams to widen them into broad, rolling hills and plains scores or hundreds of miles wide. (See Figs. 13 and 14.) The necessary altitude may have varied from time to time, but the duration of the proper conditions was very long. The elevation was not merely high enough to allow the reduction of

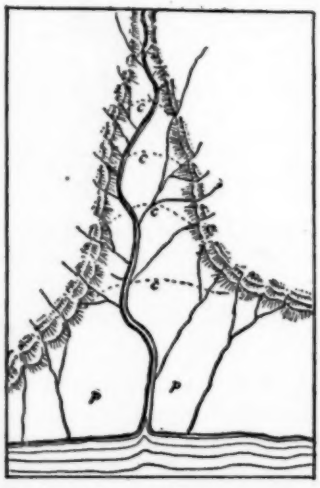


FIG. 2.—MAP OF A PLATEAU BEING TRANSFORMED INTO A VALLEY (*c c c*), WHICH IS BROADENING OUT INTO A PLAIN (*p p*). The sluggish river is only acting as a carrier for the removal of the land washes.

the table lands to a depth of five hundred feet below sea level, as is shown in the Ontario basin at this day, and the upper lakes to nearly as great a depth (Lake Erie alone being shallow, but with deep buried channels running through it), but high enough to allow for the necessary slope down the St. Lawrence Valley, not merely to the present gulf, but to the edge of the continent, some eight hundred miles from the present outlet of Lake Ontario. In short, the lake region was elevated more than twelve hundred feet higher than now, which amount itself is indicated by the soundings of the Gulf of St. Lawrence.

While the lake district was thus moderately elevated for long ages, there was an extraordinary altitude of the continent lasting for a comparatively short time, as is seen in the drowned valleys near the coastal margin of the continent; but this elevation did not last long enough for the great cañons to be cut back to Lake Ontario.

The lake basins are simply fragments of the old valleys of the St. Lawrence River and its tributaries. These normal but ancient depressions have since been obstructed so as not to allow a free drainage and are thus turned into lake basins with the district further depressed, partially below sea level. The manner in which these things were accomplished is now our theme.

DROWNED AND BURIED VALLEYS.—Fragments of the ancient valleys which existed in the lake region are discovered by the

FIG. 3.—SECTION ACROSS LAKE ONTARIO FROM POINT PETER TO PULTNEYVILLE, showing the submerged valley with the bounding escarpment.

soundings in the lakes. Throughout or across some of them great, broad channels, resembling old land valleys, such as are seen in every country, extend, and are bounded on one side or another by the steep slopes of some drowned mountain or escarpment, three hundred or four hundred feet high. Such a valley occurs in the Ontario basin, of which Fig. 3 is a cross-section. An equally good example may be seen in Lake Huron and other lakes. But at the surface these drowned valleys do not appear connected. What do they mean? We shall see.

In the lake district wells have been sunk for considerable depths for water, oil, and gas. On the now level plains the borings have often penetrated great depths of loose rock and dirt

deposits before reaching the solid strata, yet, perhaps in proximity, the bedded rocks appear near the surface of the country. These depressions are portions of ancient valleys which have been filled often to depths of five hundred feet, and in some cases probably to a thousand feet. By chains of borings the buried valleys may be traced. Their general course is frequently shown by the surface features; but without the borings their great depth would not be suspected. Thus the Dundas Valley may be taken as an example. It is situated at the head of Lake Ontario and bounded by mountain walls, but is also deeply buried by drift, as shown in Fig. 4. Some of the filled valleys are chiefly occupied with bowlder clay; in other cases with both till and stratified materials; so that their burial is not always alike. Not merely have many of the old valleys been filled with the sweepings of the highlands, but they have been further obscured by the submergence of the district beneath the modern lake waters.

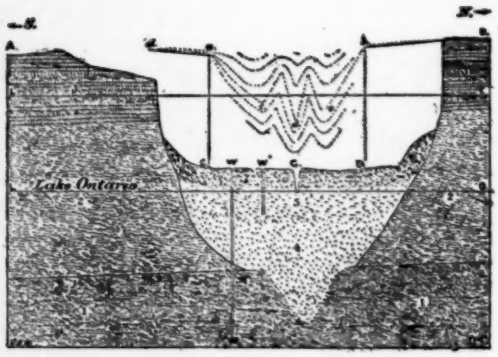


FIG. 4.—1, Hudson River formation; 2, Medina shales; 3, Niagara and Clinton dolomites with some shales; A, C, D, B, modern valley at meridian of Burlington Heights; *a*, C, D, *b*, modern valley at meridian of Dundas; *a*, *c*, *d*, *e*, *b*, sections across, deeply excavated in beds of streams in western part of the Dundas Valley; 4, bowlder clay filling ancient valley; 5, Erie clay; 6, talus from sides of escarpment; 7, old beach, one hundred and sixteen feet above lake at Burlington Heights; G, Desjardin's Canal leading from Dundas marsh to Burlington Bay; W, W, well at Royal Hotel, Hamilton; W', another well at Dundas; L, O, level of Lake Ontario; L, E, level of Lake Erie. Valley at Dundas two miles and a half wide and depth five hundred feet.

THE COURSE OF THE ANCIENT ST. LAWRENCE COMPARED WITH THAT OF THE MODERN RIVER.—In seeking for the explanation of the drowned and buried valleys, discoveries have been made showing that some of them can be connected, and thus is the change in the course of the ancient Laurentian (so named to distinguish the old water way from the modern) River established. The modern St. Lawrence River is characterized by the most remarkable system of lakes in the world. The basins are very deep, and not mere expansions of a river having no noteworthy depth. In the soundings of the lakes and in the buried valleys the connecting links of a great chain of evidence are welded together, showing that the ancient water way did not pursue the present eccentric course, but was an ordinary river valley of large size, yet its course was not everywhere coincident with that of the modern stream.

From the northern portion of the Michigan basin the channel of the ancient Laurentian River is more or less buried beneath

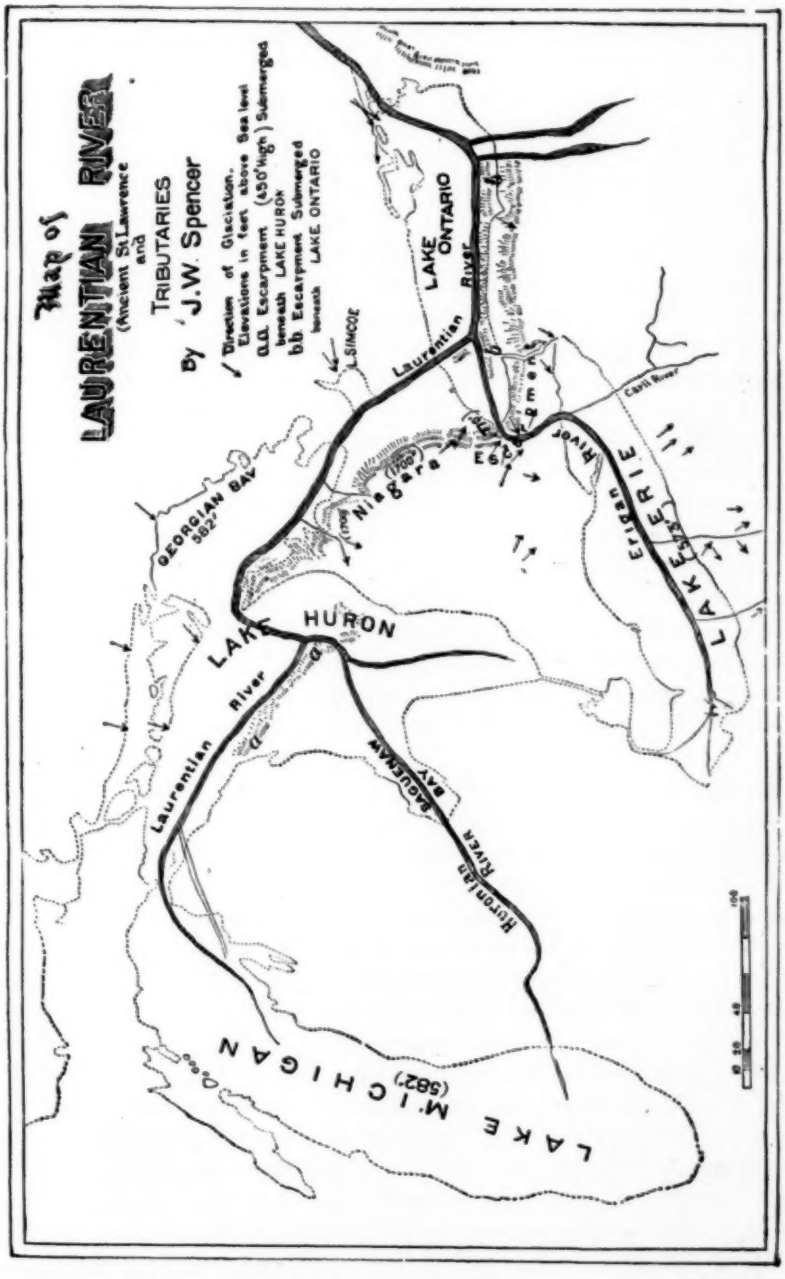


FIG. 5.—MAP SHOWING COURSE OF THE ANCIENT ST. LAWRENCE AND ITS TRIBUTARIES.

drift and also submerged in extending by way of Mackinac Straits to the Huron basin, across which its course is plainly marked at the foot of an escarpment from three hundred and fifty

to four hundred and fifty feet high, and the whole somewhat further submerged. Again it passes through the narrows across the broken mountain ridge into Georgian Bay, where the deep channel skirts the foot of another high escarpment. The old water way across these lakes is shown on map (Fig. 5).

From Georgian Bay the ancient channel is buried below drift deposits to a known depth of seven hundred feet, and almost certainly the drift reaches to a depth of one thousand feet beneath the highest obstructing ridges. The course of the channel passes through Lake Simcoe and enters the Ontario Valley about twenty miles east of Toronto, where the deep trench is made known by the soundings in the lake. The buried valley was broad and comparable to the portions through the lakes. On its western side, but some miles away, it is paralleled by the "mountain" or Niagara escarpment, which reaches to more than fifteen hundred feet above the sea. On the eastern side of the valley the plains are underlaid by solid rock, although these are often covered by drift ridges. Between these rocky boundaries the drift has been penetrated to great depths in many places, yet in the center of the channel the bottom of the filling has never been reached.

Throughout the Ontario Valley the Laurentian River flowed at the foot of a high escarpment now submerged (see Figs. 3, 5, 11). At the eastern end of Lake Ontario the channel turned toward the present outlet of the lake and then down what is now the modern course of the St. Lawrence to the sea. The origin of the barrier across the present outlet of Lake Ontario will be noticed later.

One of the great tributaries was the Huronian River, crossing the southern portion of Michigan, as shown upon the map (Fig. 5), and extending through Saginaw Bay to join the Laurentian River farther north. The Superior outlet is supposed to have crossed the upper peninsula of Michigan and joined the branch draining from the northern end of what is now Lake Michigan.

The now shallow Erie basin was then a portion of a plain across which the ancient Erigan River flowed in a valley two hundred feet or more in depth. One of the buried and submerged tributaries at Cleveland was described by Dr. J. S. Newberry, others by Dr. T. Sterry Hunt, and those near Buffalo by Dr. J. Pohlman. From the Erie basin the Erigan River crossed by a channel about forty miles west of the Niagara River, which did not then exist, and passed down the Dundas Valley (Fig. 4) into the head of the Ontario basin, and farther eastward joined the Laurentian River (Fig. 5). All the features of the ancient and drowned valleys are those characterizing ancient topography; that is to say, without the boldnesses and abruptnesses of youthful features and without great waterfalls, although rapids must have existed.

REVERSALS OF ANCIENT RIVERS IN PENNSYLVANIA AND NEW YORK.—The great changes in the water way of the Laurentian River had their counterpart in the highlands to the south of the lakes where the ancient streams were tributary to the Laurentian, in place of to the modern Ohio and Susquehanna Rivers. Among the more notable changes, the Alleghany (discovered by Mr. J. F. Carll) flowed to the Erie basin, as did also the upper Ohio (suggested by the writer, and further explained by Dr. P. Max Foshay and Mr. F. Leverett). These and other streams now reversed were tributaries of the Erigan River. In New York the upper Susquehanna and some tributaries descended through the "finger lakes" to the Laurentian River as it passed through the Ontario basin. All the old streams coming from the highlands south of the lake basins flowed through broad, V-shaped valleys, of ancient form, although of considerable depth. These valleys became filled with drift which turned the waters of the Ohio and Susquehanna Rivers to the south. This reversal in the drainage has been further assisted by the recent northward tilting of the land, to be explained later.

HOW THE ANCIENT VALLEYS WERE OBSTRUCTED.—The Laurentian Valley and its tributaries were completed before the ice age. Indeed, the high elevation of the continent during the culmination of that period did not last long enough for the deepening of the channels of the main valley, as they could scarcely be affected until a great cañon had been excavated from the continental margin for eight hundred miles to the Ontario basin, which was not the case.

As for the modification of the ancient topography by glacial action, it could have been only slight, and does not appear to have been more than the sweeping of loose geological dust into the valleys, or on to the highlands to the south. The absence of any great plow is shown by the direction of the scratches on the rock surfaces, which lines are everywhere at great angles to the walls and sides of the lake basins, and nowhere parallel to them, as must have been the case if the valleys had been plowed out by ice in any form. This crucial test and many other features had not been applied fifteen years ago, when the writer commenced these researches. Now this fancy of closet geologists has vanished before the application of facts. Yet the work of the ice age was complex, and it is immaterial to the study of the lakes how it was performed. In one way only does it come within the limit of this subject, and that is in the phenomena of the ancient valleys being filled by drift, whether stratified or not. It was this filling of the old channels with drift that closed the ancient drainage of the Laurentian Valley, which at a later date gave rise to the lake basins. But the barriers of the lakes were further exagger-

ated by the tilting of the land, which will be noted later. The closing of the old water ways ends the history of the ancient Laurentian River. When the river began to flow again, the lacustrine epoch was established.

SUBMERGENCE AND RE-ELEVATION OF THE LAKE DISTRICT.—After the obstruction of the valleys with drift, the whole lake region was submerged; but this depression is best treated of in the rising of the land which has brought the evidence to view.

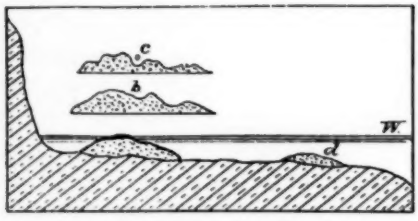


FIG. 6.—SECTION SHOWING THE FLOOR OF A CUT TERRACE ON WHICH RESTS A BEACH. *b* and *c*, beaches broken into ridgelets; *d*, a frontal sand bar; W, old water level.

As the waves beat upon the shores, the beaches, terraces, sea cliffs, sea caves, etc., become characteristic of coast lines. When the water sinks or the land rises, the various stages of the deserted shore remain and record the recession of the waves. The preservation of the old coast lines is often so perfect as to furnish easy identification of their character, as may be seen in Figs. 6 and 7, which represent sections of old beaches. Behind them lagoons often occur, and the entrances of bays are often barred across with beaches, as is shown in Fig. 8.

The resemblance between modern and ancient shores is further illustrated in Figs. 9 and 10, where great bowlder pavements are shown, marking the modern and deserted strands. In valleys, although broad, beaches do not occur, but they are replaced by terraces.

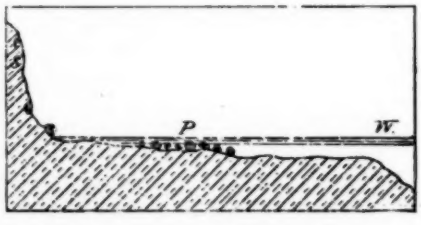


FIG. 7.—SECTION SHOWING THE FLOOR OF A CUT TERRACE WITHOUT BEACH, BUT WITH BOWLDER PAVEMENT. P, bowlder pavement; W, old water level.

The deserted beaches and terraces in the lake region occur at all altitudes, where such could be preserved. But in order to find the remains of old shore lines continuous over long distances, it is necessary to descend to the levels where the water was more or less confined in the western and central portions of the lake district, for until a recent date there were no barriers toward the northeast sufficiently high to hold the waters of the lakes above tide. In the prenatal lake epoch, such an embayment called for in the last sentence covered two hundred thousand square miles of the lake region, and has been named Warren Gulf. As there was no land barrier to this gulf in the northeastern direction, and for the

exclusion of the sea, of which there is no evidence, some have supposed that these waters of the lake district were held at high altitudes by glacial dams for long ages. This hypothesis, notably advocated by Prof. G. K. Gilbert, although based upon negative evidence to explain some difficulties, which are also applicable to southern regions even within the tropics, has retarded the researches into the history of the lakes, and had it been followed would have prevented the discovery of some of the greatest changes in the geography of northeastern America. Indeed, the greater portion of the modern elevation of the region has been

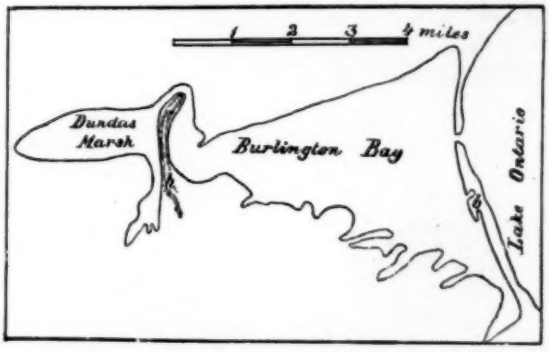


FIG. 8.—MAP OF THE WESTERN END OF LAKE ONTARIO. *b*, Burlington Beach, separating Burlington Bay from the lake; *h*, Burlington Heights, an ancient beach one hundred and eight to one hundred and sixteen feet high, separating Dundas marsh from Burlington Bay.

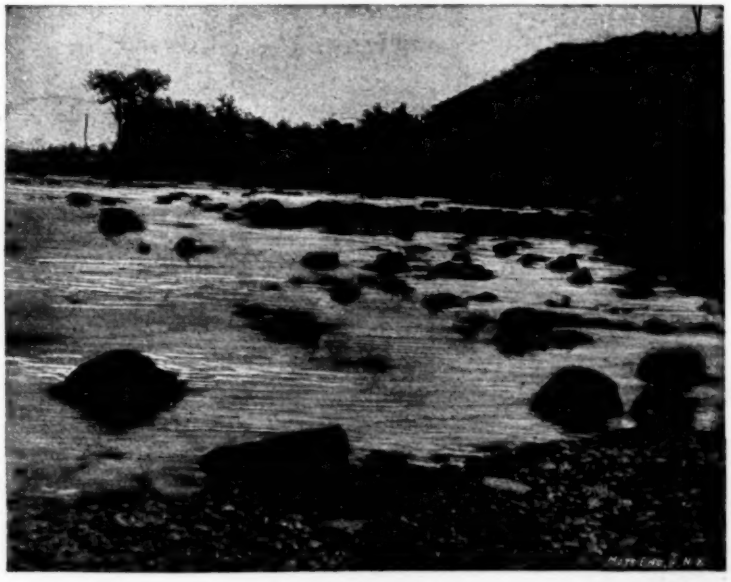


FIG. 9.—MODERN BOWLDER PAVEMENT ON GEORGIAN BAY, east of the end of Blue Mountains of Collingwood, Ontario.

recorded in the tilting of the beach lines recognized by all. But the period of glacial conditions was prior to the lacustrine,

which commenced with the submergence of the lake district to sea level.

THE TILTING OF THE ANCIENT SHORE LINES.—The shore lines of ponds, lakes, or seas are alike water levels. In this respect the

FIG. 10.—ANCIENT BOWLDER PAVEMENT OF ALGONQUIN BEACH, whose crest rises one hundred and eighty-seven feet above Georgian Bay, upon the northeast side of Blue Mountains of Collingwood, Ontario.

elevated coast lines present a striking difference from those now being formed, for the abandoned strands are everywhere tilted toward the northeast (see Figs. 11, 12, 15).

The tilted beach represents the deformation of the Algonquin beach. At the head of Lake Erie the deformation of the old water planes is not over a very few inches in a mile, while it

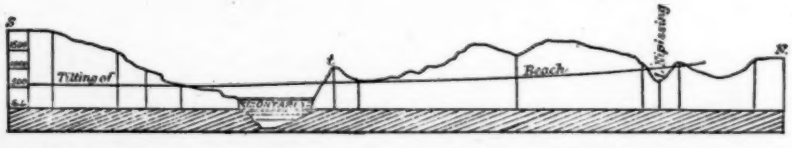


FIG. 11.—SECTION OF THE LAKE DISTRICT FROM THE HIGHLANDS OF NEW YORK TO THOSE OF THE LAURENTIAN HILLS NORTH OF LAKE HURON, ALONG A LINE PASSING THROUGH BUFFALO AND LAKE NIPISSING. Length of section, four hundred miles; heights given in feet; *t* is a ridge of drift north of Lake Ontario. The tilted beach represents the Algonquin plain deformed.

increases toward the northeast, so that it amounts to four feet per mile northeast of Lake Huron, and seven feet per mile near the outlet of Lake Ontario and north of the Adirondack Mountains, to which locality the writer himself has traced the deserted shores

all the way from the head of Lake Michigan. This gentle deformation of the surface of the country when carried over such long distances gives rise to the great physical reliefs of the mountain regions of the north and east, which were much lower before the lake epoch than now, as is apparent if the tilting be straightened out, as may be seen in the sections given. Furthermore, the character of the river courses at the surface of the country north of the lake regions indicates that even in the ice age the relatively high reliefs north of the lakes did not obtain.

THE GULF EPOCH.—In the re-elevation of the lake district after the post-glacial submergence, when the continent was high enough to partially inclose a large gulf, already referred to, to which the name of Warren Water has been given, or more correctly Gulf, there were several water connections through the valleys to the south and west of it. Its last stage as one body of water is marked by the Forest beach, as shown on the map (Fig. 13). Upon the further rise of the land the surface of Warren Gulf fell below the level of the Forest beach for a depth of a hundred and fifty feet. The movement was gradual, without striking

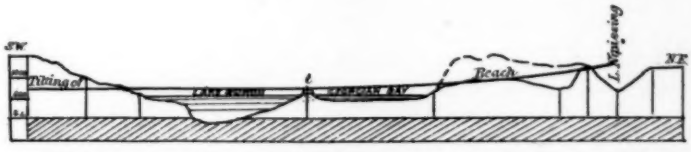


FIG. 12.—SECTION FROM THE MICHIGAN HIGHLANDS BACK OF ALPINA TO THE LAURENTIAN HIGHLANDS BEYOND LAKE NIPISSING. Length of section, three hundred and thirty miles. The tilted beach represents the deformation of the Algonquin beach.

interruptions, for there is no intervening strand, as the water did not remain at one level long enough to leave beaches. Warren water was now broken up into two great gulfs; the one called the Algonquin, occupying the basins of Lakes Superior, Michigan, and Huron, and opening to the northeast, through the strait to the Ottawa Valley, as is shown on the map (Fig. 13); the other was the Lundy Gulf, occupying most of Erie basin, and extending over the Ontario Valley at a great height. In the region of Nipissing Strait the two gulfs united.

From the deserted shores of these waters, which are now tilted up so much to the northeast, free communication between the lake region and Hudson Bay is indicated, for the Laurentian highlands are now rarely more than fifteen hundred feet above the sea and commonly less. Of course, there was free communication to the Atlantic Ocean by way of the St. Lawrence and also southward of the Adirondacks. These various characteristics and changing conditions would require a volume to tell all that we know about them, and this has been partly done in Duration of

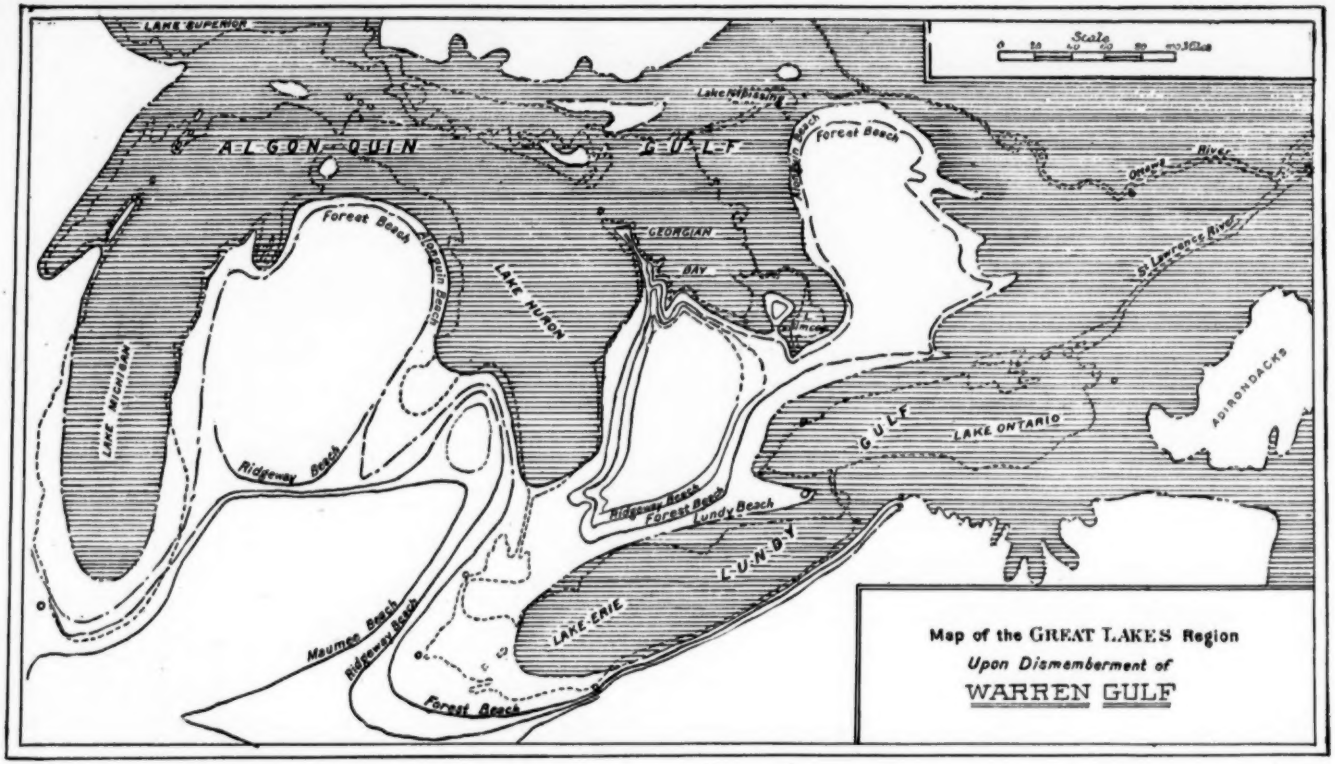


FIG. 13.—MAP OF WARREN WATER, BOUNDED BY FOREST BEACH, AND ITS SUCCESSORS. Surveyed shores represented by solid lines; partly surveyed, by broken lines; modern lakes, by dotted lines.

Niagara Falls and the History of the Great Lakes, by the writer, and published by the Commissioners of Niagara Falls Reservation, under the presidency of Hon. Andrew H. Green.*

THE BIRTH OF THE GREAT LAKES.—This marks only an episode in the chain of events which are being described, when the waters fell three hundred feet below the Algonquin and Lundy planes. Although the subsidence of the waters was not continuous and left some evidences of temporary pauses, yet the long rest was not reached until they had sunk to the level of the Iroquois beach. By this time the land had risen so high, and, as there were no sufficient barriers, the upper lakes sunk far within their present basins, as is shown on the map (Fig. 14). Still, the waters of these upper lakes discharged by way of the narrow Nipissing Strait.

Lake Erie at this time had its birth, but then it was a very small body of water, as shown on the map. The Niagara district was then covered with a strait expanded into a lakelet, and afterward a river at first without a fall. In the further sinking of the water to the Iroquois level the falls of Niagara commenced their history, and then there was a comparatively long rest, but Ontario was still a gulf, as shown on the map (Fig. 14).

The plane of the Iroquois shore was at identically or nearly the same level as the Nipissing beach (of Taylor) at the outlet of Lake Huron by way of the Ottawa Valley. It is not apparent, and it is theoretically improbable, that the Nipissing River was characterized by more than a gentle slope, for by the time that the land rose high enough to produce a rapid river the water of the upper lakes had changed their outlet into Lake Erie. The proof of these changes rests in the tilting of the beaches, which aggregates several hundred feet (see Fig. 12).

BARRIER TO LAKE ONTARIO.—Still, the land has continued to rise, and the deformation since the Iroquois episode amounts to more than before that date. The tilting at the head of Lake Ontario becomes an absolute elevation above the sea, amounting to three hundred and sixty-three feet, and at the northeastern corner of the Adirondacks it is fifteen hundred feet, while near the outlet of Lake Ontario it is seven hundred and thirty feet. This warping of the continent is illustrated in Fig. 15, and to it is due the barrier (to a large extent) which retains the waters of the Ontario basin at an elevation of two hundred and forty-seven feet above the sea.

SINKING AND SUBSEQUENT GROWTH OF THE MODERN LAKES AND CHANGE OF OUTLETS.—The continuing elevation of the con-

* The surveys of the deserted shore lines of the lakes have been mostly made by Messrs J. W. Spencer, G. K. Gilbert, A. C. Lawson, and F. B. Taylor.

tinent lowered all the waters of the lake region until their levels depended upon the rims of the lake basins from which the waters overflowed. The upper lakes were the first to sink far within

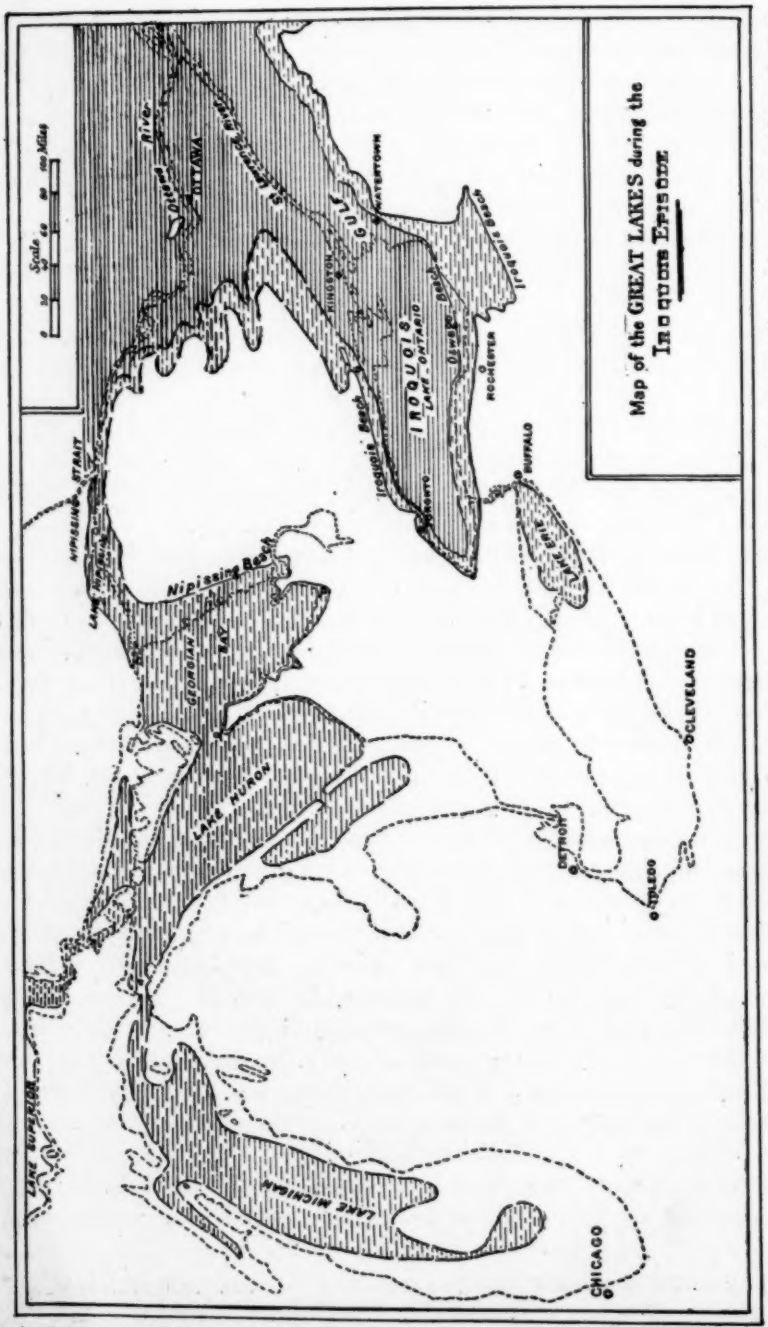


FIG. 14.—MAP OF THE EARLY LAKES. Broken shading represents extension of the early lake epoch; solid shading, a lower stage of Iroquois Gulf before the birth of Lake Ontario; modern lakes, by dotted lines.

their basins (see Fig. 14), but later even the Iroquois Gulf was contracted so as not to occupy even the head of the present Ontario basin (see Fig. 14).

The great deformation of the whole region since the close of the Iroquois episode has from that day to this been slowly raising the northeastern rims of the lake basins so as to cause them to flood more and more the lowlands and valleys at their southwestern extremities, and even to raise the waters so high as to cover some of the deserted shores in those directions. At the same time the waters are leaving their old margins at their northeastern ends, as shown on the map (Fig. 14).

The changes have not been quite simultaneous in the different basins, as the heights of the lake barriers and the rate of terrestrial movements have not been uniform. Thus, in terms of Niagara Falls, it is estimated that the Iroquois Gulf sank below the Iroquois plane about fourteen thousand years ago; but that the

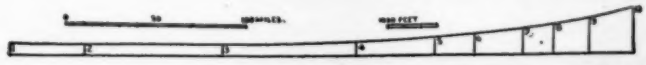


FIG. 15.—SECTION SHOWING THE TILTING OF THE IROQUOIS BEACH SOUTH OF LAKE ONTARIO AND THE ST. LAWRENCE RIVER AS FAR AS THE NORTHEAST CORNER OF THE ADIRONDACKS.

waters of Lake Huron, which had been emptying by way of the Nipissing Strait for twenty-four thousand years, were turned into Lake Erie only eight thousand years ago. Again, after the waters of the Ontario basin had sunk much below the present western margin of the lakes, they were rising again to near their present height only some three thousand years ago.

Of the absolute amount of rise of the continent we do not know, for the axis of uplift has not been ascertained, but it is evidently in the interior of the continent. The differential rate of elevation varies, being about a foot and a quarter a century in the Niagara district, two feet northeast of Lake Huron, and nearly four feet north of the Adirondacks.

THE FUTURE DRAINAGE OF THE UPPER LAKES INTO THE MISSISSIPPI RIVER.—With the land rising as at present, it will be only a matter of time until the northeastern rim of Lake Erie will be so high that the drainage must turn into Lake Huron, and thence by way of Lake Michigan and the Chicago Canal into the Mississippi, and Niagara Falls will then end their life history. Some fifteen hundred years ago there was a barrier about a mile north of the present site of the falls that had risen so high in the general regional uplift as to actually cause some of the waters of the upper lakes to overflow where the Chicago Canal is now being built; but, owing to the peculiar buried valley just behind this ridge crossing Niagara River, when the falls had passed the barrier, before the change of outlet of the upper lakes from the Ni-

agara to the Mississippi was completed, the upper lakes were rapidly lowered, and this re-established the life of the Niagara for some time longer. Upon the basis of calculations made it would appear that the change of outlet for the upper lakes from the Niagara to the Mississippi will not be more than another five thousand years hence—to us living a matter of indifference, but only showing how the present days are simply passing events in the history of the lakes. In the meanwhile the waters of Lake Ontario will more and more flood the head of its basin. However, the end of the lakes is so far removed in geological time that, until such great changes in the configuration of the land shall have obtained of which we have no prophetic vision, the lakes will continue to exist.

AGE OF THE GREAT LAKES.—When the rate of movement of the earth's crust, as determined in the history of Niagara Falls, is applied to the deserted strands of Warren Water and its successors, it is estimated that since the commencement of the Warren epoch fifty thousand or sixty thousand years have elapsed. This estimate, although based upon the most analytical knowledge obtainable, can, after all, be regarded as only approximate. The time ratio tells us that the lakes are still youthful; although in terms of solar years very old, yet perhaps not older than the human race.

The vicissitudes between the end of the ice age proper and the birth of Warren Water are too little known to enter into any proportional division of time, except that the ice age culminated prior to or at the date of the closing of the old valleys with drift.

The Great Lakes are the most striking feature of the eastern part of the continent, yet what we know of their history has been mostly discovered within the last few years. In this sketch only some of the more important and generalized results have been given. Many of the observations are beyond doubt, but there is plenty of room for students to add to our knowledge and correct our imperfect work. While the history of the lakes can be told with considerable certainty, the attempt at computing their age in terms of solar years has the same fascination, although not so extravagant, as the speculations concerning the antiquity of the earth itself, as the former question probably comes within the human period.

HARVARD College Observatory publishes a list of fourteen new variable stars of long period, in addition to those previously announced, which have been discovered by Mrs. Fleming from the examination of Henry Draper memorial photographs. The spectrum of one of these stars is of the fourth type, while all the other stars have spectra of the third type, with the hydrogen lines also bright.

DR. NANSEN'S "THROWING STICK."

By JOHN MURDOCH.

THE report that reached us last February to the effect that Dr. Nansen's adventurous expedition had actually succeeded in reaching the pole, naturally set everybody to reviewing the reasons which led him to adopt his peculiar plan. Among the facts which led him to believe that there was a steady current flowing westward across the pole, there has been frequent mention of an Alaskan *throwing stick* picked up on the southwest coast of Greenland.

Many have doubtless wished to know what a "throwing stick" is, and how it could be thought to give such conclusive evidence of a drift from western America to Greenland. As I had a hand in collecting and working out the evidence that made this little piece of wood so valuable, I propose to try and answer these two questions.

In the first place, a "throwing stick," "throwing board," or "spear thrower," as it is sometimes called, is a contrivance for casting a javelin or harpoon, which is employed by various savage races, such as the Australians, some South American tribes, and especially by the Eskimos, among whom its use is almost universal. Roughly speaking, it is a narrow grooved board a foot or so long, with one end cut into a handle and the other provided with a stud or spur for the butt of the spear to rest against. It is used thus: Grasping the handle as he would a sword, the man fits the shaft of the spear into the groove, with the butt resting against the stud, steadying the spear with the finger. Then, extending his arm and bending back his hand till the spear lies horizontal, he aims at the mark and propels the weapon by a quick forward jerk of the stick. In this way I have seen the Eskimo boys casting their forked javelins at wounded waterfowl.

There is a very large number of Eskimo throwing sticks in the National Museum at Washington, collected from all the different branches of the race. These have been very carefully studied by Prof. Otis T. Mason, one of the curators of the museum, and he has found that these implements differ greatly from each other in their details, while all are made on the same general plan. For instance, one kind will have a plain handle, while another will have projecting pegs, or holes or sockets, to give a firmer hold for the fingers, and so on.

Moreover, he has shown that each division of the Eskimo race has its own pattern of throwing stick, so that, with the help of his illustrations, one can tell, on seeing a throwing stick, whether

it came from Greenland or Hudson Bay, or from Alaska, and even what part of Alaska it came from.

I had spent two years among the Alaskan Eskimos when I was one of the naturalists of the Point Barrow Expedition in 1881–'83, and was especially interested in anything concerning them, particularly about their implements and weapons, as I had made a thorough study of these while preparing the report on the ethnological results of the expedition. Consequently, my curiosity was immediately aroused by a little notice that I accidentally ran across in the Norwegian scientific paper *Naturen*. Speaking of the meeting of the Videnskabs-selskab (Scientific Society) of Christiania, on June 11, 1886, the paper said that the curator of the museum exhibited a throwing stick found among driftwood at Godthaab, Greenland, different from those used in Greenland, but just like those used in Alaska. It was suggested that it had made the same journey as the "Jeannette relics" found at Julianehaab. Now, I have heretofore been inclined to be rather skeptical about the "Jeannette relics," but here, it seemed to me, was something that could be corroborated. I felt sure that if I could see the specimen, or a good drawing of it, I could, with the help of the museum collections (I was employed at the Smithsonian Institution at the time), make absolutely sure whether it was Alaskan or not.

At that time I was in correspondence with Dr. Rink, the famous authority on the Eskimos of Greenland, since deceased, but who was then living in Christiania. So I wrote to him for information, and soon received all that I wanted, with a carefully drawn outline of the specimen. There was no doubt about it at all! It was perfectly Alaskan in pattern, and, moreover, so like specimens from a certain region near Bering Strait that one could almost be certain that it came from there. I at once wrote to Dr. Rink, telling him of my conclusions.

On the strength of my identification of the specimen Dr. Rink published an article in the journal of the Danish Geographical Society, reviewing the whole history of the implement, and in doing so produced more evidence of the authenticity of the "find." It seems that Dr. Rink picked up the specimen himself while serving as an official of the Danish Government at Godthaab. This at once disposes of any suspicion of its being a "plant." It was lying on the beach among the driftwood, and though he and his Eskimo companions recognized it as different from anything used in Danish Greenland, he laid it aside without paying particular attention to it, fancying it came from East Greenland, as it is well known that the driftwood found on the west coast of Greenland comes down the eastern shore with the current and turns up round Cape Farewell. He kept it till 1886,

when the museum at Christiania received a valuable collection of Eskimo implements from East Greenland, collected by the expedition of Captain Holm and Lieutenant Garde. He then gave his "throwing stick" to the museum, as probably coming from the same region. To his surprise, it was found entirely different from the East Greenland implements, and the Norwegian traveler Jakobsen, who had spent many years in Alaska, suggested the resemblance to the Alaskan pattern, which gave rise to the notice that I saw in *Naturen*.

So, from all this, two things were pretty certain: First, that the stick was made in Alaska; and, second, that it was picked up on the beach at Godthaab. Now, how could it have got there? It surely could not have drifted round by way of the Northwest Passage, for that way is barred by such a network of islands that the stick would undoubtedly have been stranded long before it reached Greenland.

Some people have said, "A sailor on an American whaleship might have brought it home with him from Bering Sea, and taken it to Greenland," but any one who is familiar with the customs of American whalemen knows that the same ships never go to the North Pacific and to Davis Strait, and that very few men in the fleet have been to both regions. Moreover, the American whaleships keep over on the other side of the strait. It is very unlikely that the stick could have reached Godthaab in that way. As for the suggestion which has been made that it was dropped somewhere off the Atlantic coast from a ship coming home to New Bedford from Bering Sea, that may be dismissed in a few words. If it were dropped near shore, it would fall into the inshore current and drift south; while if it were dropped farther off, the Gulf Stream would take it to Iceland or Norway.

But it is well known that a current sets north through Bering Strait into the Arctic Ocean, and that north of the strait the current moves steadily westward, as shown by the drift of the Jeannette. It is very easy to believe that the stick drifted in this way, keeping on till it met the current that sweeps down between Iceland and Greenland, and then turned northward again round Cape Farewell. Indeed, it is hard to see how it could have got there otherwise.

So this is the way that the finding of this little piece of wood came to be a link in the chain of evidence that led Dr. Nansen to form his adventurous plan of trusting his stout little vessel to the current which he believed would take him over the very pole.

For my part, I believe that he was right, and that, even if the present rumor turns out to be untrue, there is a very good prospect that he will attain his object.

CO-ORDINATION OF OUR EDUCATIONAL INSTITUTIONS.

By Dr. EDWARD H. MAGILL,
EX-PRESIDENT OF SWARTHMORE COLLEGE.

THE common consensus of thoughtful minds in these latter days has been gradually tending more and more toward the proper co-ordination and correlation of our educational institutions. In a comparatively new country like ours it may naturally be supposed that, as the need for various grades of these institutions has arisen, the want has not always been supplied with a sufficiently careful consideration of the needs of those of other grades, and that, as a result, the general educational interests of the country require some readjustment and reorganization. It should be observed in the beginning that no censure is intended to be applied to any institution or class of institutions for their present status, as this has resulted from the progressive stages of their growth and development, and no sudden or violent change is contemplated or desired. The general outline here to be presented is rather an ideal system for future realization, toward which all may gradually work as their surroundings and circumstances may permit.

Within the past few years a new class of educational institutions has been introduced from abroad, which have received, in their name, the impress of their foreign origin. Of course, we allude to the kindergarten schools, which may now be regarded as the foundation of our present educational system, the culminating point of which is the university. The value of this new importation is no longer seriously questioned by educators, and we cordially accept it here as supplying a need which may be satisfactorily filled by the devotion to it of about three years of the life of a child. In these three years, from the age of three to six, with competent trained teachers, the little ones receive a training of the hand, the eye, the ear, the voice, and the mind that tells powerfully upon all the subsequent years of their school and college life; and the social, moral, and unsectarian religious element of their natures receives in these early years a most profound and lasting impression. With this foundation, entering upon the primary grade at six, this can well be completed in three years, from six to nine, and after these six years of school life the intermediate grade can be well covered in three years more, from the age of nine to twelve. This outline presupposes also the saving of much valuable time by omitting studies which belong to a more mature stage of mental development, and especially much of the time devoted to the foundation of mathematical studies, which should

come chiefly later in the course, language studies taking their just place in the earlier years. We next come to the grammar-school grade, so called, and educators are now beginning to see that this grade, occupying four years, from the age of twelve to sixteen, after the admirable preparation received in the lower grades, should prepare students to enter upon a college course. To this end, too, the requirements for admission to college should be materially lowered instead of being as now too often advanced. This was distinctly announced by Prof. Remsen at Johns Hopkins University in his address before the College Association of the Middle States and Maryland last year, when he made it perfectly evident to all that the best educational interests would be advanced by calling a halt to the colleges which are raising their requirements for admission, thus admitting students younger and graduating them earlier to continue their work in the universities or enter upon the duties of active life. From the age of sixteen to twenty should be devoted to the college course, beginning with few electives in the Freshman year and gradually increasing their number as the course approaches completion. On graduating from college the students should receive their first degrees from these institutions, and all subsequent post-graduate degrees should be earned in and conferred by the universities, in which all college graduates who can devote the additional time and means required should be encouraged to pursue their studies for three or perhaps four years more. As the university course would include the professional courses, students would thus come out at twenty-three or twenty-four years of age equipped thoroughly, so far as our educational institutions can equip them, to cope successfully with the important problems and duties of active life.

It will be seen that for the thorough application of such an outline of study, each institution, of whatever grade, should aim to do its own work most thoroughly and well, and attempt no part of that of an institution of a higher or lower grade. Thus the student should pass from the kindergarten to the primary, from the primary to the intermediate, from the intermediate to the grammar school, from the grammar school to the college, and from the college to the university, entering each institution, as the rule (remarkable exceptions will occur, but they should not change the rule), in the lowest class of that institution, and passing through its entire curriculum in the department selected. No other course than this can assure the successful working of any regularly organized system of instruction.

It is very true that most of our colleges had connected with them in their origin preparatory departments as a necessity of their existence. This necessity has existed, and in some cases still continues to exist, and it is no part of this paper to condemn

such union while circumstances require it. Our universities are of later growth, and are with scarcely an exception in this transition period, with large undergraduate classes. With these, as with the colleges, we have no controversy, for they are doing excellent work, and their circumstances in these earlier stages seem to require this union, which, under other circumstances, we should earnestly deprecate.

We say they are doing excellent work, but this is because of the completeness of their organization in other respects and the able faculties which they employ. But surely they could do worthier work were these faculties free to give their time and attention to graduate students, and no longer hampered and hindered by the instruction of large classes of undergraduates. And the present condition of things is equally a disadvantage to our colleges, whose students, to rival those of universities, aspire to what is quite beyond undergraduate work, and thus wholly overlook the plain line of distinction between a college and a university, consisting as it does so largely of the separating line between *acquisition of the known* and *investigation of the unknown*. And hence it is, too, that a number of colleges, even those of low grade, and *especially* those of low grade, aspire to be called universities. The changes proposed will do away with all this, and colleges and universities will each do better work in their respective fields.

We shall then hail with joy, as advancing the best interests of education in this country, the time when all our universities shall have reached the stage of admitting to their courses no undergraduate students.

It will be seen that to adopt the outline here presented to our educational system it will be needful, in the four grammar-school years (high schools and academies being left out of the scheme), to prepare students properly for entering upon one of the courses in college, the ancient or the modern letters course, or the science course, the requirements for the admission to each being now rapidly equalized by our best colleges. With the nine years of most thorough training in the three earlier grades, from the age of three to twelve, and under teachers who are themselves no mere experimenters, but thoroughly trained to their work, this will be found quite possible, and the preparation will be even better made than under our present system. Of course, the plan involves a complete training in all the grades, including a professional training for teaching in the university before entering upon the responsible position of teacher of the young in any one of the grades, even of the lowest. When this time arrives, teaching as a means of eking out a scanty subsistence, or as a stepping-stone to something higher, with wholly inadequate professional preparation, will be done away. It is, indeed, an expensive method of

supporting those in limited circumstances to intrust them with the delicate and most responsible duties of training the young for their life's work, and so future generations will undoubtedly regard it.

As we said in the beginning, we present this co-ordination and correlation of our educational institutions as an ideal scheme, toward which we should ever aspire, but which we can not expect to see realized by any sudden or violent changes, or, indeed, in full operation within the next quarter of a century. But that something analogous to that which is here presented will be found feasible and practicable, and to harmonize fully with the institutions of this free country of ours, and enable us to attract students from abroad in great numbers instead of sending them, as now, to complete their education in Germany, France, or England, we are most thoroughly convinced. And the more hopefully do we look forward at this time to such a consummation now that the favorite scheme of Washington and our other early Presidents for a great national university at Washington, as the crowning glory of our educational institutions, is likely to be realized at an early day and provided for by an adequate endowment.

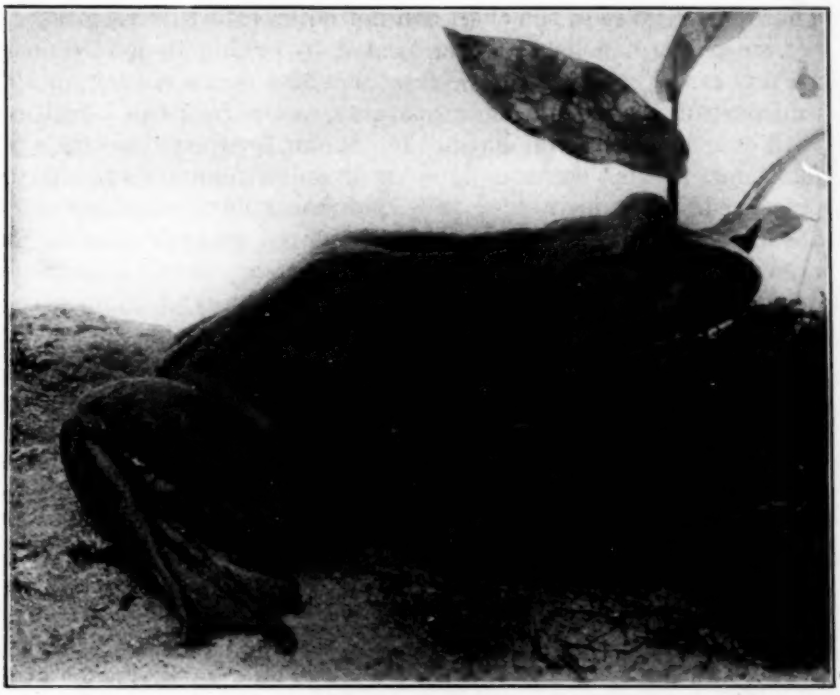
FROGS AND THEIR USES.

By R. W. SHUFELDT, M. D.

DURING the last half century or more, and especially during the latter part of this time, Science has made use of a variety of natural objects and living animals in her laboratories to demonstrate the laws and facts of biology. The fundamental phenomena of plant and animal life have been taught by Huxley by placing before his students in the laboratory such material as yeast, and such types of vegetable and animal organization as protococcus, proteus animalculæ, bacteria, molds, stoneworts, ferns, bean plant, bell animalculæ, polyps, mussels, crayfish, and frogs. Foster and Balfour wrote an entire work upon the elements of embryology, using for the purpose only the egg and chick of the common barnyard fowl. For what is true of the hen's egg and its complete development is true in the main for the eggs and development of all forms of animal life, from the highest mammal to the lowest vertebrate known. In the selection of these types for work in the scientific laboratory, teachers have been chiefly guided in their choice by the accessibility of the form selected to the largest number of students of all countries, and by taking an animal of the widest geographical distribution. Thus Cuvier selected the perch as a type for the study

of the structure of fishes; frogs' eggs, tadpoles, and frogs have been almost universally used, while birds and mammals have been largely studied through our investigation of the fowl, the pigeon, and the rabbit. Of course, hundreds upon hundreds of other plant and animal organizations have been most exhaustively worked out, but students always, or very frequently, date back to the manuals upon the biology of these old standbys. Gray's Human Anatomy is a very good example of one of these aids to the study of a single vertebrate species—a monograph, as it were. Some day, Mivart's Cat will hold a similar place as a work of reference. I have already referred above to the use of the frog as an animal whereby the biological student may gain much information; indeed, I do not believe there is a single animal anywhere that, for this or other purposes, has come into more general use. If a common frog be fully studied in all its phases, and a comparative study be made of its entire structure, together with its physiology and habits, the student has made a long stride toward the comprehension of life processes in general, and will find himself landed far within the domain of biology, and very liberally equipped to investigate almost any problem zoölogy may have to offer. In addition to this, ever since physiology came to be a science, frogs have been used by the researchers in that department whereby to demonstrate some of the grandest truths that men have brought to light. Especially is this true with respect to the study of the muscular and nervous systems. Physicists also use them extensively, and the medical expert in experimenting with, or detecting the presence of, a variety of poisons. The circulation of the blood, and the processes of inflammation as seen under the microscope, are now studied by thousands of students in the laboratories the world over, and they are nowhere better seen than in the web of a frog's foot. Some of the more obscure actions of the heart have been made clear by the study of the entire circulatory apparatus of this useful batrachian. The action of woorara in destroying the properties of the motor nerves has been demonstrated by Bernard upon frogs; while Matteucci, by the use of a frog's leg, has shown the contrasted action of the direct and the inverse current. The remarkable experiments of Marshall Hall and of Pflüger, on the reflex action of the spinal cord, where the most delicate animal organization was necessary, were made possible by the use of frogs; while another experimenter has worked out through them the physiological action of strychnine. Indeed, some of the most important facts in physiology have been, and constantly are to-day being, demonstrated upon frogs; and the list of such conquests, and the light they shed upon this most useful kind of knowledge, are altogether too long to enter upon here. Much is to be learned by simply studying the action

of a large, healthy frog in a tub of water. His mode of respiration under such circumstances is a lesson of itself, while the beautiful rhythmic action of his limbs in propelling himself through the water or diving beneath it is almost a complete treatise on the art of swimming. Its action upon land is quite as instructive, and the marvelous leaps and dives of one of these creatures can be studied for a long time with a very considerable degree of profit. Colton, in his Practical Zoölogy, especially invites the student to "notice how the frog sits when at rest," and I can heartily indorse the suggestion. Artists frequently miss it when



COMMON BULLFROG. One half natural size. From a photograph by Dr. Shufeldt.

they come to represent a frog in the normal attitude of rest; and in my Scientific Taxidermy for Museums I was particular to devote an entire plate to this subject, showing the plaster cast of a large bullfrog taken from one of them in this position. But it is the camera that catches these attitudes the best of all for us, and last summer I paid very considerable attention to the photography of adult living frogs. Most of these results were as fine as could be desired, and one of the best of them is presented here as an example (see figure). If one will take the trouble to compare this with almost any of the pictures of frogs—upon direct lateral aspect—that illustrate the very numerous works upon natural

history, he will be surprised to find how wide many of the latter are of the mark with respect to the attitude the animal really assumes in Nature.

When a frog is at rest in this sitting position he presents us with a number of external characters that are very interesting to study. It will be noticed that the little apertures forming the nostrils open and shut alternately, while at the same time the mouth is closed, and the rising and falling of the skin covering the throat show that a pumping operation is going on. This is just exactly what is taking place, and the air pouring in through the nostrils has to be swallowed in order to be conveyed to the lungs. There being no ribs, the chest can not enter into this respiratory act, so a frog can be easily suffocated by prying its mouth open for a time. The skin in these creatures also forms a very important part of the respiratory apparatus, and a frog can be killed with ease by tying him out in the hot sun, for the cutaneous surface must be kept continually moist in order to have its functions preserved. This is insured in very dry weather by its power to absorb a quantity of water which is stored away for use in an internal nonurinary reservoir, from which receptacle it is excreted over the surface of the body. When one suddenly picks up a frog during the long, dry months of summer, it often voids a quantity of this clear water in a succession of jets. The large, round eye of the bullfrog is peculiar in some respects, for, if we tickle its corneal surface with some light object, as a straw, it will be noticed that the thick upper lid, covered as it is by the common integuments, has very little movement, while on the other hand, as the animal rotates its eyeball inward and beneath this, there at the same time passes up over the organ the thinner, somewhat transparent, lower eyelid. This shield, entirely covering the ball, as it does, reminds one of the structure seen in birds, and called the nictitating membrane. As soon as the irritation is withdrawn, the animal again opens his eye, which, by the way, with its truly beautiful iris, is, in my opinion, one of the most elegant structures seen in Nature. Posterior to and below the eye we meet with a flat, oval area, also covered by the skin, which is the tympanum of the ear. One might possibly mistake this for a thin flat bone in the skin, but this latter tissue in frogs is perfectly smooth and is completely devoid of either scales or osseous plates. There is an American genus of frogs, however (*Ceratophrys*), a few representatives of which form an exception to this rule. If we puncture the eardrum in the frog, it will be found that a fine pig's bristle may be passed by a natural passage through the opening made into the mouth. It goes through the *Eustachian tube*, a canal which is also present in man and other vertebrates, permitting, as it does, the vibrations of the tympanum. The fact

that the frog is devoid of any neck; that its spine makes a hump near the middle of its back; the characters of its two pairs of limbs; and other external features, are all too well known to the intelligent observer and reader to require special description here. There is another thing we must notice, however, and its presence is not generally observed nor appreciated. If we watch carefully at the distal end of the backbone, upon either side of it, it will be seen that the skin pulsates at those points with sufficient force to make it apparent to the eye. These pulsations are performed by the posterior pair of *lymph hearts*. Now, the lymph hearts have nothing to do with the circulation of the blood as performed by the heart, but they, on the other hand, pump the lymph contained in the large lymphatic vessels into the veins. There are two pairs of these lymph hearts—the pair just noticed and an anterior pair, which are below the margin of the shoulder blade, upon either side, and near the lateral processes of the third vertebra. They are muscular organs endowed with the power of contraction, and are extremely important ones in the internal economy of the frog.

In a brief essay, such as I am now writing, it will by no means be practicable to enter upon the extremely interesting subject of the internal structure of the frog. Even to touch upon this ever so lightly would require a small volume to print it. Not a few books are in circulation now devoted largely to the anatomy of these animals, and others no doubt will appear from time to time. A few years ago the distinguished British naturalist, Prof. St. George Mivart, devoted an entire treatise to The Common Frog, and it is truly a most instructive work. In it he describes a number of different kinds of frogs, but what gives the book its special biological significance is that he discusses the life history of these tailless batrachians, and their anatomy and physiology, with a variety of other forms that are either closely affined to them or more or less remotely connected. In summing up, Prof. Mivart shows the differences existing between a frog and a fish, a frog and a reptile, a frog and a bird, a mammal, and so on; and indeed what a frog really is, and he claims it to be "a tailless, lung-breathing, branchiate vertebrate, with four limbs typically differentiated, undergoing a complete metamorphosis, and provided with teeth along the margins of the upper jaw." This last character is one that distinguishes the frogs from the toads, while from other batrachians the frogs are at once separated by the absence of a tail.

In the United States we have at least fifty or sixty different species and subspecies of frogs and tree frogs, belonging to a number of different genera. The typical genus is the genus *Rana*, and to it belongs our common bullfrog (*Rana Catesbiana*), it at

the same time being the species that furnishes the legs so much enjoyed by many epicures. When Huxley gave his biological chapter on these animals, he used the Anglo-continental types, *R. temporaria* and *R. esculenta*, the latter form being the one used for the table in Europe. One of the most interesting species that have been described is the one discovered by Mr. Wallace in Borneo a number of years ago. It has been popularly called the "flying frog," from the fact that it has toes of great length, and these are fully webbed to the tips. If the animal wishes to descend from the top of a high tree it has only to make the leap, and by spreading out its toes it converts its feet into four veritable parachutes, and thus this little aërial batrachian reaches *terra firma* in safety. Among the most curious types are the tree frogs; and Gibson says these "are readily distinguished from all others by having the ends of their toes dilated into knobs or disks, generally provided with a sticky secretion, by means of which they can cling to the leaves and branches of trees. They are small, elegant, and exceedingly active creatures, the males possessing loud voices, of which they make copious use during the breeding season and on the approach of rain." Frogs have from remote times been regarded as weather prophets, and at the present day, in some parts of Germany, the European tree frog (*Hyla arborea*) is used as a barometer. A few of them are placed in a tall bottle provided with miniature ladders, the steps of which they ascend during fine weather, seeking the bottom again on the approach of rain.

Anatomical structures of a variety of kinds are characteristic of different species of frogs, having to do with the *voice organs*. So it is that many croak, some chirp, and some almost bellow. Many emit noises most disagreeable to all ears, while others give vent to sounds that under some circumstances are quite enjoyable. Darwin says, "Near Rio de Janeiro I used often to sit in the evening to listen to a number of little *Hylæ* [tree frogs], which, perched on blades of grass close to the water, sent forth sweet, chirping notes in harmony." This, however, is not the case with another species that occurs in Surinam, also a tree frog, endowed with an extremely disagreeable voice, and, what is worse, they congregate together in great numbers, and then, when they unite in their piping, they have been known to drown the orchestra of the Paramaribo theater.

Frogs live principally upon insects, and these they capture with their peculiarly formed tongue. This organ is soft and extensible, being at the same time covered with a viscid secretion. Anteriorly it is closely attached to the floor of the mouth, while behind it is to a large degree free. The free part is thrust forward when the frog desires to capture an insect, and the latter

sticking to the tongue, it is with marvelous rapidity whipped back to the frog's throat and swallowed. Frogs will also seize some of their prey in other ways, and for this purpose they use their jaws and teeth, which latter are to be found on the palate and upper jaw. I have frequently taken them with hook and line, the former being baited only with a small piece of red flannel. So far as I know at present there is no species of frog that has come to the knowledge of science that possesses a poison gland or apparatus. Some of them, however, secrete from their skin pungent and disagreeable secretions. These are protective in a way, and prevent other animals from preying upon them. In a species of *Hyla* I met with upon the island of Cuba this secretion was so strong as to bring water to the eyes, and upon one occasion when handling one of these creatures and then rubbing my eyes the lids of the latter swelled tremendously, and this condition was only reduced after proper treatment lasting over three or four days. There is another tree frog (*Hyla micans*) in which this secretion of the body is slimy and profuse, and it at the same time possesses luminous properties, which probably also serves to protect the animal from its enemies. There are many beautiful examples of protective mimicry to be seen among frogs, especially among the brown or the green tree frogs, or other arboreal forms that are mottled and shaded with greens, grays, and browns. These species usually feed at night and are still all day, being detected only with difficulty, as they rest upon leaves, limbs, or rocks. Some are brilliantly colored, but they are nonedible varieties, and so their high-colored skins serve them as a protection.

Fossil frogs first occur in the Tertiary, but they become more abundant in the Miocene period.

A SCIENTIFIC way to settle international boundary disputes is suggested by Mr. Hugh Robert Mill, who, speaking of the proposal of the International Geographical Congress for a series of official maps on a uniform scale, says, in Nature: "If the governments of all countries were jointly to take this matter up, survey all unsurveyed lands which they claim, and submit the uncertain boundaries, which are yet uncomplicated by gold mines, to an international commission of geographers, to be decided on the basis of a new map on purely geographical principles, the expense would be many times saved by the security which well-defined frontiers give, and a magnificent contribution to science would be effected."

THE region of the delta of the Yukon is described by W. H. Dall, in his paper on Alaska as it Was and Is, as remarkable for being the breeding place of myriads of waterfowl, some of which are peculiar to the Alaskan region. Nearly a hundred species gather there, and one of them comes all the way from north Australia, by the coasts of China and Japan, to lay its eggs and rear its young in this spot.

THE METRIC SYSTEM.*

By HERBERT SPENCER.

(*With a Letter from Sir Frederick Bramwell.*)

I.

ADVOCATES of the metric system allege that all opposition to it results from "ignorant prejudice." This is far from being the fact. There are strong grounds for rational opposition, special and general; some already assigned and others which remain to be assigned. I may fitly put first a carefully-reasoned expression of dissent from a late man of science of high authority.

In 1863 Sir John Herschel published an essay, in which, after referring to an attempt made during the preceding session to carry through Parliament a bill establishing the French metrical system in this country, and anticipating that the bill (said to have been confirmed in principle) would be again brought forward, he proceeded to contrast that system with a better one to be reached by making a minute modification in our own unit of measure. The following extract will sufficiently indicate the line of his argument:—

Let us now see how far the French metre as it stands fulfills the requirements of scientific and ideal perfection. It professes to be the 10,000,000th part of the quadrant of the meridian passing through France from Dunkirk to Formentera, and is, therefore, scientifically speaking, a local and national and not a universal measure. . . . The metre, as represented by the material standard adopted as its representative, is too short by a sensible and measurable quantity, though one which certainly might be easily corrected.

[In the appendix it is shown that according to the latest measurements the error is 1-163d part of an inch on the metre.]

Sir John goes on to say that "were the question an open one what standard a new nation, unprovided with one and unfettered by usages of any sort, should select, there could be no hesitation as to its adoption (with that very slight correction above pointed out)"; and he then continues—

The question now arising is quite another thing, viz.:—Whether we are to throw overboard an existing, established, and, so to speak, ingrained system—adopt the metre as it stands for our standard—adopt, moreover, its decimal subdivisions, and carry out the change into all its train of consequences, to the rejection of our entire system of weights, measures, and coins. If we adopt the metre we can not stop short of this. It would be a

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* Most of the matter in this article appeared originally in the form of unsigned letters n the London Times. The interest in the subject in the United States warrants its republication in the Monthly, with a view to which Mr. Spencer has kindly consented to allow his authorship of the letters to be made known.

standing reproach and anomaly—a change for changing's sake. The change, if we make it, must be complete and thorough. And this is in the face of the fact that England is beyond all question the nation whose commercial relations, both internal and external, are the greatest in the world, and that the British system of measures is received and used, not only throughout the whole British Empire (for the Indian "Hath" or revenue standard is defined by law to be 18 British imperial inches), but throughout the whole North American continent, and (so far as the measure of length is concerned) also throughout the Russian Empire. . . . Taking commerce, population, and area of soil then into account, there would seem to be far better reason for our Continental neighbors to conform to our linear unit could it advance the same or a better *a priori* claim than for the move to come from our side. (I say nothing at present of decimalization.)

Sir John Herschel then argues that the 10,000,000th part of the quadrant of a meridian, which is the specified length of the metre, is, on the face of it, not a good unit of measure, inasmuch as it refers to a natural dimension not of the simplest kind, and he continues thus:—

Taking the polar axis of the earth as the best unit of dimension which the terrestrial spheroid affords (a better *a priori* unit than that of the metrical system), we have seen that it consists of 41,708,088 imperial feet, which, reduced to inches, is 500,497,056 imperial inches. Now, this differs only by 2,944 inches, or by 82 yards, from 500,500,000 such inches, and this would be the whole error on a length of 8,000 miles which would arise from the adoption of this precise round number of inches for its length, or from making the inch, so defined, our fundamental unit of length.

After pointing out that the calculation required for correlating a dimension so stated with the earth's axis is a shorter one than that required for correlating such dimension with the quadrant of a meridian, Sir John Herschel argues that—

If we are to legislate at all on the subject, then the enactment ought to be to increase our present standard yard (and, of course, all its multiples and submultiples) by one precise thousandth part of their present lengths, and we should then be in possession of a system of linear measure the purest and most ideally perfect imaginable. The change, so far as relates to any practical transaction, commercial, engineering, or architectural, would be absolutely unfelt, as there is no contract for work even on the largest scale, and no question of ordinary mercantile profit or loss, in which one *per mille* in measure or in coin would create the smallest difficulty.

Hitherto I have said nothing about our weights and measures of capacity. Now, as they stand at present, nothing can be more clumsy and awkward than the numerical connection between these and our unit of length.

And then, after pointing out the way in which the slight modification of the unit of linear measure described by him could be readily brought into such relation with the measures of capacity and weight as to regularize them, he goes on:—

And thus the change which would place our system of linear measure

on a perfectly faultless basis would, at the same time, rescue our weights and measures of capacity from their present utter confusion.

In presence of the opinion thus expressed and thus supported by evidence, we ought, I think, to hear nothing more about "ignorant prejudice" as the only ground for opposition to the metric system now being urged upon us. But, before proceeding to give adverse reasons of my own, let me quote a further objection—not, it may be, of the gravest kind, but one which must be taken into account. Writing from Washington, Prof. H. A. Hazen, of the United States Weather Bureau, published in Nature of January 2, this year, a letter of which the following extracts convey the essential points:—

The metric system usually carries with it the Centigrade scale on the thermometer, and here the whole English-speaking world should give no uncertain sound. In meteorology it would be difficult to find a worse scale than the Centigrade. The plea that we must have just 100° between the freezing and boiling points does not hold; any convenient number of degrees would do. The Centigrade degree (1°·8 F.) is just twice too large for ordinary studies. The worst difficulty, however, is in the use of the Centigrade scale below freezing. Any one who has had to study figures half of which have *minus* signs before them knows the amount of labor involved. To average a column of 30 figures half of which are *minus* takes nearly double time that figures all on one side would take, and the liability to error is more than twice as great. I have found scores of errors in foreign publications where the Centigrade scale was employed, all due to this most inconvenient *minus* sign. If any one ever gets a "bee in his bonnet" on this subject and desires to make the change on general principles it is very much to be hoped that he will write down a column of 30 figures half below 32° F., then convert them to the Centigrade scale, and try to average them. I am sure no English meteorologist who has ever used the Centigrade scale will ever desire to touch it.

But now, having noted these defects, which may perhaps be considered defects of detail, since they do not touch the fundamental principle of the metric system, I propose, with your permission, to show that its fundamental principle is essentially imperfect and that its faults are great and incurable.

II.

In reply to my inquiries, a French friend, member of the Conseil d'Etat, after giving instances of nonconformity to the metric system, ended by saying:—"En adoptant le système métrique décimal, on n'a pas fait disparaître tout à fait les dénominations anciennes, mais on en a fortement réduit l'emploi." [By adopting the decimal metric system, we have not made the old denominations to disappear entirely, but we have greatly reduced their use.]

It is now more than a century since, in the midst of the French Revolution, the metric system was established. Adoption of it

has been in the main compulsory. As French citizens have been obliged to use francs and centimes, so must they have been obliged to use the State-authorized weights and measures. But the implication of the above statement is that the old customs have survived where survival was possible; the people can still talk in sous and ask for fourths, and they do so. Doubtless "ignorant prejudice" will be assigned as the cause for this. But one might have thought that after three generations, daily use of the new system would have entailed entire disappearance of the old, had it been in all respects better.

Allied evidence exists. While in the land of its origin the triumph of the metric system is still incomplete, in one of the lands of its partial adoption, America, the system has been departed from. It will be admitted that men engaged in active business are, by their experience, rendered the best judges of convenience in monetary transactions; and it will be admitted that a Stock Exchange is, above all places, the focus of business where facilitation is most important. Well, what has happened on the New York Stock Exchange? Are the quotations of prices in dollars, tenths, and cents? Not at all. They are in dollars, halves, quarters, eighths; and the list of prices of American securities in England shows that on the English Stock Exchange quotations are not only in quarters and eighths, but in sixteenths and even thirty-seconds. That is to say, the decimal divisions of the dollar are in both countries absolutely ignored, and the division into parts produced by halving, re-halving, and again halving is adopted. Worse has happened. A friend writes:—"When I was in California some twenty years ago the ordinary usage was to give prices in 'bits,' the eighth of a dollar—a 'long bit' was fifteen cents, a 'short bit' was ten cents. If one had a long bit and paid it one got no change—if one gave a short one no supplement was asked." Thus lack of appropriate divisibility led to inexact payments—a retrogression.

Perhaps an imaginary dialogue will most conveniently bring out the various reasons for dissent. Let us suppose that one who is urging adoption of the metric system is put under cross-examination by a skeptical official. Some of his questions might run thus:—

What do you propose to do with the circle? At present it is divided into 360 degrees, each degree into 60 minutes, and each minute into 60 seconds. I suppose you would divide it into 100 degrees, each degree into 100 minutes, and each of these into 100 seconds.

The French have decimalized the quadrant, but I fear their division will not be adopted. Astronomical observations throughout a long past have been registered by the existing mode of measurement, and works for nautical guidance are based upon it. It would be impracticable to alter this arrangement.

(You are right. The arrangement was practically dictated by Nature. The division of the circle was the outcome of the Chaldean division of the heavens to fit their calendar: a degree being, within 1-60th, equivalent to a day's apparent motion of the Sun on the ecliptic. And that reminds me that I do not find in your scheme any proposal for redivision of the year. Why do you not make 10 months instead of 12?

A partial decimalization of the calendar was attempted at the time of the French Revolution; a week of ten days was appointed, but the plan failed. Of course, the 365 days of the year do not admit of division into tenths; or, if ten months were made, there could be no tenths of these. Moreover, even were it otherwise, certain deeply-rooted customs stand in the way. Many trading transactions, especially the letting of houses and the hiring of assistants, have brought the quarter-year into such constant use that it would be very difficult to introduce a redivision of the year into tenths.)

(Just so; and it occurs to me that there is a deeper reason. Ignoring the slight ellipticity of the earth's orbit, a quarter of a year is the period in which the Earth describes a fourth of its annual journey round the Sun, and the seasons are thus determined—the interval between the shortest day and the vernal equinox, between that and the longest day, and so on with the other divisions.)

The order of Nature is doubtless against us here.

(It is against you here in a double way. Not only the behavior of the Earth, but also the behavior of the Moon conflicts with your scheme. By an astronomical accident it happens that there are 12 full moons or approximately 12 synodic lunations in the year; and this, first recognized by the Chaldeans, originated the 12-month calendar, which civilized peoples in general have adopted after compromising the disagreements in one or other way. But there is another division of time in which you are not so obviously thus restrained. You have not, so far as I see, proposed to substitute 10 hours for 12, or to make the day and night 20 hours instead of 24. Why not?

Centuries ago it might have been practicable to do this; but now that timekeepers have become universal we could not make such a redivision. We might get all the church clocks altered, but people would refuse to replace their old watches by new ones.

I fancy conservatism will be too strong for you in another case—that of the compass. The divisions of this are, like many other sets of divisions, made by halving and re-halving and again halving until 32 points are obtained. Is it that the habits of sailors are so fixed as to make hopeless the adoption of decimal divisions?

(Another reason has prevented—the natural relation of the cardinal points. The intervals included between them are necessarily four right angles, and this precludes a division into tenths.)

Just so. Here, as before, Nature is against you. The quadrant results from space-relations which are unchangeable and necessarily impose, in this as in other cases, division into quarters. Nature's lead has been followed by mankind in various ways. Beyond the quarter of a year we have the moon's four quarters. The quarter of an hour is a familiar division, and also the quarter of a mile.) Though the yard is divided into feet and inches, yet in every draper's shop yards are measured out in halves, quarters, eighths, and sixteenths or nails. Then we have a wine merchant's quarter-

cask, we have the fourth of a gallon or quart, and, beyond that, we have for wine and beer, the quarter of a quart, or half-pint. Even that does not end the quartering of measures, for at the bar of a tavern quarterns of gin, that is quarter-pints of gin, are sold. Evidently we must have quarters. What do you do about them? Ten will not divide by four.

The Americans have quarter dollars.

And are inconsistent in having them. Just as in France, notwithstanding the metric system, they speak of a quarter of a litre and a quarter of a livre, so in the United States they divide the dollars into quarters, and in so doing depart from the professed mode of division in the very act of adopting it—depart in a double way. For the tenths of a dollar play but an inconspicuous part. They do not quote prices in dollars and dimes. I continually see books advertised at 25c., 75c., $1.25c., $1.75c., and so forth, but I do not see any advertised as $1.3 dimes or 4 dimes, etc. So that, while not practically using the division theoretically appointed, they use the division theoretically ignored.

It may be somewhat inconsistent, but there is no practical inconvenience.

I beg your pardon. If they had a 12-division of the dollar, instead of a 10-division, these prices $1.25 and $1.75 would be $1..3 and $1..9. And not only would there be a saving in speech, writing, and printing, but there would be a saving in calculation. Only one column of figures would need adding up where now there are two to add up; and, besides decreased time and trouble, there would be fewer mistakes. But leaving this case of the dollar, let us pass to other cases. Are we in all weights, all measures of length, all areas and volumes, to have no quarters?

Quarters can always be marked as ·25.

So that in our trading transactions of every kind we are to make this familiar quantity—a quarter, by taking two-tenths and five-hundredths? But now let me ask a further question—What about thirds? In our daily life division by three often occurs. Not uncommonly there are three persons to whom equal shares of property have to be given. Then in talk about wills of intestates one hears of widows' thirds; and in Acts of Parliament the two-thirds majority often figures. Occasionally a buyer will say—"A half is more than I want and a quarter is not enough; I will take a third." Frequently, too, in medicines where half a grain is too much or not enough, one-third of a grain or two-thirds of a grain is ordered. Continually thirds are wanted. How do you arrange? Three threes do not make ten.

We can not make a complete third.

You mean we must use a makeshift third, as a makeshift quarter is to be used?

No; unfortunately that can not be done. We signify a third by ·3333, etc.

That is to say, you make a third by taking 3 tenths, *plus* 3 hundredths, *plus* 3 thousandths, *plus* 3 ten-thousandths, and so on to infinity!

Doubtless the method is unsatisfactory, but we can do no better.

Nevertheless, you really think it desirable to adopt universally for measurements of weight, length, area, capacity, value, a system which gives us only a makeshift quarter and no exact third.

These inconveniences are merely set-offs against the great conveniences.

Set-offs you call them! To me it seems that the inconveniences outweigh the conveniences.

But surely you can not deny those enormous evils entailed by our present mixed system which the proposed change would exclude.

I demur to your assertion. I have shown you that the mixed system would in large part remain. You can not get rid of the established divisions of the circle and the points of the compass. You can not escape from those quarters which the order of Nature in several ways forces on us. You can not change the divisions of the year and the day and the hour. It is impossible to avoid all these incongruities by your method, but there is another method by which they may be avoided.

You astonish me. What else is possible?

I will tell you. We agree in condemning the existing arrangements under which our scheme of numeration and our modes of calculation based on it proceed in one way, while our various measures of length, area, capacity, weight, value, proceed in other ways. Doubtless, the two methods of procedure should be unified; but how? You assume that, as a matter of course, the measure system should be made to agree with the numeration system; but it may be contended that, conversely, the numeration system should be made to agree with the measure system—with the dominant measure system, I mean.

I do not see how that can be done.

Perhaps you will see if you join me in looking back upon the origins of these systems. Unable to count by giving a name to each additional unit, men fell into the habit of counting by groups of units and compound groups. Ten is a bundle of fingers, as you may still see in the Roman numerals, where the joined fingers of one hand and the joined fingers of the two hands are symbolized. Then, above these, the numbering was continued by counting two tens, three tens, four tens, etc., or 20, 30, 40 as we call them, until ten bundles of ten had been reached. Proceeding similarly, these compound bundles of tens, called hundreds, were accumulated until there came a doubly compound bundle of a thousand; and so on. Now, this process of counting by groups and compound groups, tied together by names, is equally practicable with other groups than 10. We may form our numerical system by taking a group of 12, then 12 groups of 12, then 12 of these compound groups; and so on as before. The 12-group has an enormous advantage over the 10-group. Ten is divisible only by 5 and 2. Twelve is divisible by 2, 3, 4, and 6. If the fifth in the one case and the sixth in the other be eliminated as of no great use, it remains that the one group has three times the divisibility of the other. Doubtless it is this great divisibility which has made men in such various cases fall into the habit of dividing into twelfths. For beyond the 12 divisions of the zodiac and the originally associated twelvemonth, and beyond the twelfths of the day, and beyond those fourths—submultiples of 12—which in sundry cases Nature insists upon and which in so many cases are adopted in trade, we have 12 ounces to the pound troy, 12 inches to the foot, 12 lines to the inch, 12 sacks to the last; and of multiples of 12 we have 24 grains to the pennyweight, 24 sheets to the quire. Moreover, large sales of small articles are habitually made by the gross (12 times 12) and great gross ($12 \times 12 \times 12$). Again, we have made our multiplication table go up to 12 times 12, and we habitually talk of dozens. Now,

though these particular 12-divisions are undesirable, as being most of them arbitrary and unrelated to one another, yet the facts make it clear that a general system of twelfths is called for by trading needs and industrial needs; and such a system might claim something like universality, since it would fall into harmony with those natural divisions of twelfths and fourths which the metric system necessarily leaves outside as incongruities.

But what about the immense facilities which the method of decimal calculations gives us? You seem ready to sacrifice all these?

Not in the least. It needs only a small alteration in our method of numbering to make calculation by groups of 12 exactly similar to calculation by groups of 10; yielding just the same facilities as those now supposed to belong only to decimals. This seems a surprising statement; but I leave you to think about it, and if you can not make out how it may be I will explain presently.

III.

The promised explanation may most conveniently be given by reproducing, with various alterations and additions, a letter I wrote about the matter last November twelvemonth to a distinguished man of science. Omitting the name, the letter ran thus:—

The inclosed memoranda concerning advantages to be derived from the use of 12 as a fundamental number were written more than 50 years ago, and have since been lying unused among my papers.

I send them to you because you have lately been expressing a strong opinion in favor of the metric system, and of course your opinion will weigh heavily. From the days when the accompanying memoranda were set down I have never ceased to regret the spreading adoption of a system which has such great defects, and I hold that its universal adoption would be an immense disaster.

Of course I do not call in question the great advantages to be derived from the ability to carry the method of decimal calculation into quantities and values, and of course I do not call in question the desirableness of having some rationally originated unit from which all measures of lengths, weights, forces, etc., shall be derived. That as promising to end the present chaos the metric system has merits goes without saying. But I object to it on the ground that it is inconvenient for various purposes of daily life, and that the conveniences it achieves may be achieved without entailing any inconveniences.

One single fact should suffice to give us pause. This fact is that, notwithstanding the existence of the decimal notation, men have in so many cases fallen into systems of division at variance with it, and especially duodecimal division. Numeration by tens and multiples of ten has prevailed among civilized races from early times. What then has made them desert this mode of numeration in their tables of weights, measures, and values? They can not have done this without a strong reason. The strong reason is conspicuous—the need for easy division into aliquot parts. For a long period they were hindered in regularizing their weights and measures by the circumstance that these had been derived from organic bodies and organic lengths—the carat and grain, for instance, or the cubit, foot, and digit. Organic weights and lengths thus derived were not defi-

nite multiples one of another, and where they were approximate multiples the numbers of these were irregular—would not conform to any system. But there early began, as among the Chaldeans, arrangements for bringing these natural measures into commensurable relations. By sexagesimal divisions (60 being the first number divisible both by 10 and 12), the Babylonian cubit was brought into relation with the Babylonian foot. The stages of change from nation to nation and from age to age can not, of course, be traced, but it suffices to recognize the fact that the tendency has been toward systems of easily-divisible quantities—the avoirdupois pound of 16 ounces, for instance, which is divisible into halves, into quarters, into eighths. But, above all, men have gravitated toward a 12-division, because 12 is more divisible into aliquot parts than any other number—halves, quarters, thirds, sixths—and their reason for having in so many cases adopted the duodecimal division is that this divisibility has greatly facilitated their transactions. When counting by twelves instead of by tens, they have been in far fewer cases troubled by fragmentary numbers. There has been an economy of time and mental effort. These practical advantages are of greater importance than the advantages of theoretical completeness. Thus, even were there no means of combining the benefits achieved by a method like that of decimals with the benefits achieved by duodecimal division, it would still be a question whether the benefits of the one with its evils were or were not to be preferred to the benefits of the other with its evils—a question to be carefully considered before making any change.

But now the important fact, at present ignored, and to which I draw your attention, is that it is perfectly possible to have all the facilities which a method of notation like that of decimals gives, along with all the facilities which duodecimal division gives. It needs only to introduce two additional digits for 10 and 11 to unite the advantages of both systems. The methods of calculation which now go along with the decimal system of numeration would be equally available were 12 made the basic number instead of 10. In consequence of the association of ideas established in them in early days and perpetually repeated throughout life, nearly all people suppose that there is something natural in a method of calculation by tens and compoundings of tens. But I need hardly say that this current notion is utterly baseless. The existing system has resulted from the fact that we have five fingers on each hand. If we had had six on each there would never have been any trouble. No man would ever have dreamt of numbering by tens, and the advantages of duodecimal division with a mode of calculation like that of decimals would have come as a matter of course.

Even while writing I am still more struck with the way in which predominant needs have affected our usages. Take our coinage as an example. Beginning at the bottom we have the farthing (¼ penny), the halfpenny and penny (or one-twelfth of a shilling); next we have the threepenny piece (¼ shilling), the 6*d.* piece (½ shilling), and the shilling; and then above them we have the eighth of a pound (2*s.* 6*d.*), the quarter of a pound (5*s.*), and half-pound (10*s.*). That is to say, daily usage has made us gravitate into a system of doubling and again doubling and redoubling; and when until recently there existed the 4*d.* piece we had the convenience of a third as well as a half and a quarter—a convenience which would have been retained but for the likeness of the 3*d.* and 4*d.* coins. And observe

that this system of multiples and sub-multiples has its most conspicuous illustration in the commonest of all processes—retail payments—and that, too, in the usages of a nation which is above all others mercantile.

Now it seems to me that the two facts—first, that in early days men diverged from the decimal division into modes of division which furnished convenient aliquot parts, and, second, that where, as in America, the decimal system has been adopted for coinage, they have in the focus of business fallen into the use of aliquot parts in spite of the tacit governmental dictation—not only prove the need for this mode of division, but imply that, if the metric system were universally established, it would be everywhere traversed by other systems. To ignore this need, and to ignore the consequences of disregarding it, is surely unwise. Inevitably the result must be a prevention of the desired unity of method; there will be perpetual inconveniences from the conflict of two irreconcilable systems. [At the time this prophecy was made, I did not know that in California the "long bits" and "short bits" of the dollar already illustrated this conflict of systems and its evils.]

I fully recognize the difficulties that stand in the way of making such changes as those indicated—difficulties greater than those implied by the changes which adoption of the metric system involves. The two have in common to overcome the resistance to altering our tables of weights, measures, and values; and they both have the inconvenience that all distances, quantities, and values named in records of the past must be differently expressed. But there would be further obstacles in the way of a 12-notation system. To prevent confusion different names and different symbols would be needed for the digits, and to acquire familiarity with these, and with the resulting multiplication table, would, of course, be troublesome; perhaps not more troublesome, however, than learning the present system of numeration and calculation as carried on in another language. There would also be the serious evil that, throughout all historical statements, the dates would have to be differently expressed; though this inconvenience, so long as it lasted, would be without great difficulty met by inclosing in parentheses in each case the equivalent number in the old notation.

But, admitting all this, it may still be reasonably held that it would be a great misfortune were there established for all peoples and for all time a very imperfect system when with a little more trouble a perfect system might be established.

Thus far the letter. And now let me sum up the evidence. Professedly aiming to introduce uniformity of method, the metric system can not be brought into harmony with certain unalterable divisions of space nor with certain natural divisions of time, nor with the artificial divisions of time which all civilized men have adopted. As 10 is divisible only by 5 and 2 (of which the resulting fifth is useless), its divisibility is of the smallest; and having only a makeshift fourth and no exact third, it will not lend itself to that division into aliquot parts so needful for the purposes of daily life. From this indivisibility it has resulted that, though men from the beginning had in their ten fingers the decimal system ready made, they have, in proportion

as civilization has progressed, adopted, for purposes of measurement and exchange, easily divisible groups of units; and in a recent case, where the 10-division of money has been imposed upon them, they have, under pressure of business needs, abandoned it for the system of division into halves, quarters, eighths, sixteenths. On the other hand, the number 12 is unique in its divisibility—yields two classes of aliquot parts—and for this reason has been in so many cases adopted for weights, measures, and values. At the same time it harmonizes with those chief divisions of time which Nature has imposed upon us and with the artificial divisions of time by which men have supplemented them; while its sub-multiple, 4, harmonizes with certain unalterable divisions of space, and with those divisions into quarters which men use in so many cases. Meanwhile, if two new digits for 10 and 11 be used, there arises a system of calculation perfectly parallel to the system known as decimals, and yielding just the same facilities for computation—sometimes, indeed, greater facilities, for, as shown in the memoranda named in the above letter, it is even better for certain arithmetical processes.

Do I think this system will be adopted? Certainly not at present—certainly not for many generations. In our days the mass of people, educated as well as uneducated, think only of immediate results; their imaginations of remote consequences are too shadowy to influence their acts. Little effect will be produced upon them by showing that, if the metric system should be established universally, myriads of transactions every day will for untold thousands of years be impeded by a very imperfect system. But it is, I think, not an unreasonable belief that further intellectual progress may bring the conviction that since a better system would facilitate both the thoughts and actions of men, and in so far diminish the friction of life throughout the future, the task of establishing it should be undertaken.

Hence I contend that adoption of the metric system, while it would entail a long period of trouble and confusion, would increase the obstacles to the adoption of a perfect system—perhaps even rendering them insuperable—and that, therefore, it will be far better to submit for a time to the evils which our present mixed system entails.

P. S.—A mathematician and astronomer, who writes—"I am much interested in your letters and agree with almost everything," makes some comments. He says:—"It has always been an astonishing thing to me that the advocates of decimalization do not perceive that its only advantage is in computation. In every other process it is a detriment." Concerning the 12-notation, he remarks that "the advantages are notorious to all mathematicians." Apparently less impressed than I am with the advance

of knowledge from uncivilized times to our own and the breaking down of habits, now going on with accelerated rapidity, he does not share the expectation that the 12-notation "will ever be adopted in practice," the obstacles to the change being too great. But without opposing the metric system as threatening to stand in the way of a more perfect system, he opposes it as intrinsically undesirable, saying:—"I think that all that can be done is to make our coinage and measures as little decimal as possible, and our computation as decimal as may be."

IV.

From one who every month has to act as auditor, I have received a letter in which he says: "I had to go over more than £20,000 of accounts yesterday, and was very thankful that it was not in francs."

This statement, coming from a man of business, has suggested to me the question, By whose advice is it that the metric system of weights, measures, and values is to be adopted? Is it by the advice of those who spend their lives in weighing and measuring and receiving payments for goods? Is it that the men who alone are concerned in portioning out commodities of one or other kind to customers, and who have every minute need for using this or that division or subdivision of weights or measures, have demanded to use the decimal system? Far from it. I venture to say that in no case has the retail trader been consulted. There lies before me an imposing list of the countries that have followed the lead of France. It is headed Progress of the Metric System. It might fitly have been headed Progress of Bureaucratic Coercion. When, fifty years after its nominal establishment in France, the metric system was made compulsory, it was not because those who had to measure out commodities to customers wished to use it, but because the Government commanded them to do so; and when it was adopted in Germany under the Bismarckian *régime*, we may be sure that the opinions of shopkeepers were not asked. Similarly elsewhere, its adoption has resulted from the official will and not from the popular will.

Why has this happened? For an answer we must go back to the time of the French Revolution, when scientific men were intrusted with the task of forming a rational system of weights, measures, and values for universal use. The idea was a great one, and, allowing for the fundamental defect on which I have been insisting, it was admirably carried out. As this defect does not diminish its great convenience for scientific purposes, the system has been gradually adopted by scientific men all over the world; the great advantage being that measurements registered by a scientific man of one nation are without any trouble made intelli-

gible to those of other nations. Evidently moved by the desire for human welfare at large, scientific men have been of late years urging that the metric system should be made universal, in the belief that immense advantages, like those which they themselves find, will be found by all who are engaged in trade. Here comes in the error. They have identified two quite different requirements. For what purpose does the man of science use the metric system? For processes of measurement. For what purpose is the trader to use it? For processes of measurement *plus* processes of exchange. This additional element alters the problem essentially. It matters not to a chemist whether the volumes he specifies in cubic centimetres or the weights he gives in grammes are or are not easily divisible with exactness. Whether the quantities of liquids or gases which the physicist states in litres can or can not be readily divided into aliquot parts is indifferent. And to the morphologist or microscopist who writes down dimensions in subdivisions of the metre, the easy divisibility of the lengths he states is utterly irrelevant. But it is far otherwise with the man who, all day long, has to portion out commodities to customers and receive money in return. To satisfy the various wants of those multitudes whose purchases are in small quantities, he needs measures that fall into easy divisions and a coinage which facilitates calculation and the giving of change. Ask him to do his business in tenths, and he will inevitably be impeded.

"But you forget that the metric system is approved by many mercantile men, and that its adoption is urged by the chambers of commerce." No, I have not forgotten; and if I had I should have been reminded of the fact by the fears now expressed that our commerce will suffer if we do not follow in the steps of sundry other nations. The fears are absurd. French and German merchants, when sending goods to England, find no difficulty in marking them or invoicing them in English measures. And if English merchants imply that they are too stupid to follow the example in a converse way, they can scarcely expect to be believed. Surely the manufacturers who supply them with piece goods will make these up in so many metres instead of in so many yards, if asked to do so; and similarly in all cases. Or, if not, it needs but a table on the wall in the clerk's office, giving in parallel columns the equivalents of quantity in English denominations and French denominations, to make easy the needful invoicing and labeling. But it is not on this flimsiest of reasons that I wish chiefly to comment. The fact here to be specially emphasized is that merchants are not in the least concerned with the chief uses of the metric system. Their bales and chests and casks contain large quantities—dozens of yards, hundredweights, gallons. They do not deal with subdivisions of these. Whether

the retailer is or is not facilitated in portioning out these large quantities into small quantities is a question having no business interest for them. More than this is true. Not only have they never in their lives measured out fractional amounts in return for small sums of money, but they have rarely witnessed the process. Their domestic supplies are obtained by deputy, usually in considerable quantities; and neither behind the counter nor before it have they with any frequency seen the need for easy divisibility into aliquot parts. Their testimony is supposed to be that of practical men, while in respect of the essential issue—the use of weights and measures for retail trade—they have had no practice whatever.

See, then, the strange position. The vast majority of our population consists of working people, people of narrow incomes, and the minor shopkeepers who minister to their wants. And these wants daily lead to myriads of purchases of small quantities for small sums, involving fractional divisions of measures and money—measuring transactions probably fifty times as numerous as those of the men of science and the wholesale traders put together. These two small classes, however, unfamiliar with retail measuring transactions, have decided that they will be better carried on by the metric system than by the existing system. Those who have no experimental knowledge of the matter propose to regulate those who have! The methods followed by the experienced are to be rearranged by the inexperienced!

To the Editor of the Times.

SIR: I am one of those who believe that this system, in conjunction with its inevitable concomitant, decimals, is one which is absolutely incompatible with mental arithmetic, and that, whatever theorists may say to the contrary, it demands more figures to perform most ordinary sums than does our present system, when rightly applied; and, further, is much more likely to lead to error, owing to the very multiplicity of figures, and, above all, to the common error in placing the decimal point.

But, without further obtruding my views, which I am aware will carry but little weight with your readers, I desire to be allowed to send to you an extract from the Comte de Montholon's book, vol. iv, pages 213 to 218, stating the views of the First Napoleon on this point, thinking that probably this will be read with interest.

I send also an extract from "Littré," giving the meaning of the (to me) unusual term "*nombre complexe*," for which I know of no English equivalent.

I am, sir, your obedient servant,

FREDERICK BRAMWELL.

Nombre complexe (or compound number). Littré gives the following definition of it under "Complexe": "Complexe; Terme d'arithmétique. Nombre complexe, nombre composé d'unités différentes, comme nos anciennes mesures: 1 toise, 5 pieds, 9 pouces; 25 livres, 13 sous, 6 deniers, sont des nombres complexes." (*Translation:* "Arithmetical term, compound number; a number composed of different kinds of units, like our old measures: 1 toise, 5 feet, and 9 inches; 25 livres, 13 sous, and 6 deniers are compound numbers."

(*Translation.*)

Memoranda for use in a History of France under Napoleon, written at St. Helena by General Comte de Montholon, Volume IV, pp. 213–218:

The need of uniformity in weights and measures has been felt in all ages; the States-General have pointed it out many times. This good gift was expected from the Revolution. A sufficient simple law to assure it might have been drawn up in twenty-four hours, adopted, and put in operation in all France in less than a year. All that was needed was to make the unit of weights and measures of the city of Paris common to all the provinces. The Government and the artists have used them for many centuries; by sending the standards into all the communes, and enjoining the administrative officers and the courts from admitting any others, the benefit would have been operative without effort, without restriction, and without coercive laws. Instead, geometricians and algebraists were consulted upon a question which was of administrative jurisdiction. They thought that the unit of weights and measures should be deduced from a natural constant, so that it might be adopted by all nations. They thought it was not enough to provide for the advantage of forty million men; they wanted the whole universe to participate in it. They found that the metre was an aliquot part of the meridian; they made the demonstration of it and proclaimed it in an assembly composed of French, Italian, Spanish, and Dutch geometricians.

From that time a new unit of weights and measures was decreed, which did not square with the rules of the public administration, or with the tables of dimensions of all the arts, or with those of any existing machines.

There was no advantage in extending this system to the whole universe. That was, besides, impossible. The national spirit of the English and Germans was opposed to it. That Gregory VII, in reforming the calendar, made it common to all Europe, was because the reform pertained to religious ideas, and was not made by a nation, but by the power of the Church.

Meanwhile the good of present generations was sacrificed to abstractions and vain hopes, for to make an old nation adopt a new unit of weights and measures it is necessary to make over again all the rules of public administration, all the calculations of the arts—a task to frighten reason. The new unit of weights and measures, whatever it may be, has an ascending and descending scale which does not accord in simple numbers with the scale of the unit of weights and measures which has been used for centuries by the Government, men of science, and artists.

No transfer can be made from one nomenclature to the other, because what is expressed by the simplest number in the old system will have to take a composite number in the new. It will be necessary, then, to increase or diminish the amount by some fraction, so that the space or the

weight expressed in the new nomenclature shall be in simple numbers. Thus, for example, the ration of the soldier is expressed in the old nomenclature as twenty-four ounces; this is a very simple number. Translated into the new nomenclature, it gives seven hundred and thirty-four grammes and two hundred and fifty-nine thousandths. It is, then, evident that it is necessary to increase or diminish the weight so as to make seven hundred and thirty-four or seven hundred and thirty-five grammes.

All the component pieces or lines of architecture; all the pieces and tools used in watch-making, jewelry, book-selling, and all the arts; all instruments and machines, have been devised and calculated in the old nomenclature, and are expressed in simple numbers, which can be translated in the new system only into numbers composed of five or six figures. It will be necessary, therefore, to do everything over again.

The scientific men also conceived another idea wholly foreign to the benefit of unity of weights and measures: they adopted the decimal numeration, taking the metre for the unit; they suppressed all complex numbers. Nothing is more contrary to the organization of the mind, the memory, and the imagination. A toise, a foot, an inch, a line, a point, are fixed portions of extension, which the imagination conceives independently of their relations to one another; if, then, we ask for the third of an inch, the mind goes into instant operation. The length called an inch is divided into three parts. By the new system, on the contrary, the mind has, not to divide an inch into thirds, but a metre into a hundred and eleven parts. The experience of all ages had made the difficulty of dividing a space or a weight by more than twelve so evident that a new name was created for each of the divisions. If the twelfth of an inch was asked for—the operation was already performed—we had the measure called the line.

The decimal numeration was applied to all the complex numbers as a unit; and if we wanted a hundredth of a point, a hundredth of a line, a hundredth was written. By the new system, if we want to express a hundredth of a line, we have to consider its relation to the metre, and this involves us in an infinite calculation.

The divisor 12 was preferred to the divisor 10, because 10 has only two factors, 2 and 5, while 12 has four factors, 2, 3, 4, and 6.

It is true that the decimal system, generalized and adapted to the metre as the unit, gives facilities to astronomers and calculators; but these advantages are far from compensating for the inconvenience of rendering thought more difficult. The prime characteristic of every method should be that of aiding the conception and the imagination, of facilitating the memory, of giving more force to the thought.

The compound numbers are as old as man, because they are in the nature of his organization, quite as it is in the nature of the decimal numeration to adapt itself to every unit, to every complex number, and not exclusively to one unit.

Finally, they use Greek roots, and that augments the difficulties; the denominations, which may be useful for men of science, were not good for the people. The system of weights and measures was one of the greatest achievements of the Directory. Instead of letting time do its work, and being satisfied to encourage the new system by means of example and fashion, it made coercive laws and executed them vigorously.

The merchants and the citizens were vexed by affairs indifferent in

themselves, and this contributed to make unpopular an administration which put itself away from the wants and the reach of the people, violently broke with their usages, habits, and customs, as a Greek or Tartar conqueror might have done, who with uplifted rod intended to compel obedience to all his desires based upon his own prejudices and interests, regardless of those of the conquered.

The new system of weights and measures will be a subject of embarrassment and difficulties for many generations; and the first commission charged with the verification of the measure of the meridian will probably find that there are some corrections to be made. This is tormenting the people with caprices.

THE MONETARY PROBLEM.

By LOGAN G. McPHERSON.

AS has been perceived, it is by the constant exchange of human effort that human welfare is promoted, and therefore is necessarily a means whereby each portion of effort contributing to the total welfare may be measured and rewarded. This means or medium of exchange is money, and its development has been as follows:

First, there was barter, or the direct exchange of commodity for commodity. Next, there was the disposal of commodities in exchange for a generally acceptable and readily disposed of commodity, the first form of money. By reason of their suitability, one or another of the metals becomes generally used as such a commodity, and as commodities are exchanged in larger volume, metals of the greatest value are coined. Then, there is the use of paper promises to pay coin issued from various sources and accepted to the extent that their security is believed in. Then these representatives of coin gradually pass into paper representatives of value, as evidenced by the result of effort, and by means of banks paper representatives of value are offset against other paper representatives of value without the intervention of coin at all.

But the progression through barter and the use of metals as money to the use of paper representatives of value has not been uniform either in time or place. There are still tribes in out-of-the-way regions who make rude exchanges by barter, and there are races between the individuals of whom the exchange of effort is uncertain and irregular, whose currencies are composed almost exclusively of lead, tin, copper, and iron. There are not only marked points of difference between the monetary systems of different nations, but in many instances one and the same nation still uses coins of different metals, of different weights, and different degrees of fineness, the values of which are not in definite

regular ratio, and notably in the United States there are paper currencies issued from different sources and resting upon different bases.

The money in circulation in the United States amounts to between one and a half and one and three-quarter billions of dollars, divided approximately as follows: Nickel and copper coins, twenty millions of dollars; silver coin, one hundred and twenty millions of dollars; gold coin, four hundred and eighty millions of dollars; paper currency, one thousand millions of dollars.

Statistics gathered by the Comptroller of the Currency show that, of the receipts of national banks, checks form an average of about ninety per cent, only about ten per cent being composed of paper currency and coin. Other statistics, also gathered by the Comptroller of the Currency, show that in retail transactions throughout the United States the medium of exchange is composed, on an average, to the extent of about forty per cent of checks and sixty per cent of paper currency and coin. The smaller retail transactions are effected almost entirely by the use of coin; as the transactions become of greater value, the more does paper currency enter into them; as their value further increases, the greater is the use of checks, and transactions of magnitude between different localities are settled by drafts and bills of exchange.

This progression in the medium of exchange, corresponding with the progression in value of coexistent transactions, agrees with the progression in the medium of exchange in correspondence with the progression in value of transactions, as they have developed throughout history, and makes manifest the fact that the most important monetary factors at present are paper representatives, of value consisting, first, of bank notes or government notes circulating generally as currency, issued under government regulation, and secured upon widely known bases; second, of checks, drafts, promissory notes, bills of exchange, and other instruments depending for their security upon the resources of the drawers and indorsers, the extent of which is not generally known.

As these paper representatives of value form by far the greater portion of the medium of exchange, the most important point of the monetary problem is raised by the question—

How may paper representatives of value be secured, to most satisfactorily meet the requirements of a medium of exchange?

Let the conditions incident to the issue and acceptance of a paper representative of value in a simple case be considered. When, a few years ago, a humble laborer, bereft of home, property, and family by the Johnstown flood, applied to the manager of a Pittsburg mill for work, he was provided with some immediate

necessaries in exchange for his duebill, which called for five dollars. That duebill was practically his promise to expend effort in the service of the mill, to balance the efforts of others expended in producing the necessities provided him, and the manager accepted it in the belief that the laborer's effort to that value would be forthcoming. That duebill was returned to the laborer the next pay day as part of his wages, its purpose having been effected without the use of coin or bullion.

It will be perceived that the duebill, the representative of value in this instance, was accepted —

1. Because the acceptor believed in the ability of the issuer to produce desired result of human effort to the value called for by it.

2. Because the acceptor believed in the intention of the issuer to produce desired result of human effort to the value called for by it.

3. Because the value of the effort called for was definitely understood between the issuer and the acceptor, the unit of the measure of that value being one dollar, and the total measure of that value five dollars.

The duebill could not have been given general circulation, because not many people would have been confident that its value would be forthcoming. This lack of confidence may have proceeded from ignorance of the ability and intention of the issuer through lack of acquaintance with him, or from doubt in the minds of those acquainted with him as to his ability and intention. If, however, the promise of the laborer had been re-enforced by the promise of the manager that he would make its value good if the laborer did not, the duebill doubtless could have been given a certain circulation among those having knowledge of the manager's honesty and resources, and believing in the genuineness of his indorsement.

In other communities, however, among persons knowing neither the laborer nor the manager, circulation for the duebill could not have been expected. A representative of value, therefore, to have wide circulation, must be issued and assured from a source widely known to be able and honest in the intention to produce the value of effort to the amount for which it calls.

As it is by transition from the use of coin that paper representatives of value come into use, they are at first usually direct representatives of coin, and are generally accepted on the assurance that they can readily be exchanged for the amount of coin for which they call. This assurance is nearly always given by a government directly or indirectly. If it be required that gold, to the full value specified by circulating notes, be held as a basis for a paper currency, such a currency will never be adequate to supply

the monetary needs of so vast a nation as the United States. It is doubtful that even the vast increase, both present and prospective, in the production of gold will yield a supply, the proportion of which coming to the United States would be sufficient for its monetary needs under such a requirement. To the evils of a paper currency issued against silver, reference will be made hereinafter.

If paper currency apparently based upon gold be issued to a value greatly in excess of that of the gold held for its redemption, the excess of the currency above the gold, in the absence of other guarantee of its security, is speculative and unstable. If a guarantee of its security other than gold or other metal in coin or bullion be given, a new factor enters into the monetary sphere.

The United States bonds are promises to pay, based upon the ability of the Government of the United States to obtain the result of human effort to the extent of their value by the power of taxation; and as a United States national bank is required to deposit numbers of these bonds as a basis for the bank notes issued by it, the security for these notes is really the Government's power of taxation, or ultimately the result of human effort elicited by the use of that power. A considerable portion of the security for the notes of the Bank of England consists of indebtedness of the nation to the bank; and the Dominion notes of Canada are largely based upon the Government's indebtedness. A new factor succeeding and supplementing gold as the basis for monetary issue is therefore the assurance of the result of human effort to the extent necessary to maintain the expressed value of the currency.

To perceive that a paper representative of value so secured will perform every function of a coin of equal value needs only an instant's reflection. A five-dollar national bank note, for example, one of hundreds of such notes, drawn from a bank by the paymaster of a woolen mill, may be paid to one of the operatives as the measure and reward in part of the expenditure of his effort in guiding the loom. It may be paid by him to his grocer, thereby measuring and rewarding in part the efforts of men expended in producing and bringing to him potatoes, flour, coffee, sugar, bacon. It may be paid by the grocer to his landlord, and so measure and reward him in part for effort expended under his direction in erecting and finishing the building containing the grocery. It may be paid by the landlord to a servant, as the measure and reward of effort expended in keeping his house clean and preparing food for his family. It may be given by her to a shoe dealer, measuring and rewarding in part the efforts of men expended in killing cattle, tanning hides, working them into shoes, and bringing the shoes to the store whence she obtained them.

And thus that five-dollar bill may go round and round until it is deposited by some recipient in a bank, whence it may emerge and perform round after round of other service, and so on perhaps for years. In all its circuits, the thought of exchanging it for gold or silver may not enter the mind of a single person through whose hands it passes. It measures and rewards human effort; it is generally accepted because its recipients have ample confidence in the assurance of the bank, guaranteed by the Government that its value, as expressed on its face, will be preserved and maintained. They have confidence in the ability of the issuer to that end; they have confidence in the intention of the issuer to that end. The measure of value expressed by five dollars is definitely understood by them.

If other proof is required that neither coin nor bullion is essentially necessary to effect the exchange of human effort, attention need only be called to the emergency currency brought into existence by the currency famine of August and September, 1893. Clearing-house certificates, clearing-house duebills, certified checks, pay checks, negotiable certificates of deposit, bond certificates, grain-purchase notes, store orders, improvement fund orders, teachers' warrants and shingle scrip, sprang into being and measurably facilitated the exchange of human effort in many localities, especially in the West and Southwest, where mills, mines, and stores would have closed had there been nothing to take the place of the ordinary currency of the nation. These instruments in each instance were paper representatives of value as evidenced by the result of human effort; they each attained a circulation among those believing in the intention and ability of the issuers to make their expressed value good.

As it is by use of the results of human effort that further effort is made possible, as it is to obtain the result of human effort that human effort is put forth, what more logical, what more inevitable, than that the medium whereby human effort is exchanged, whereby it is measured and rewarded, be based upon the results of human effort? That is, it is by the exchange of human effort that we are fed and housed and clothed. It is by use of houses, food, and clothing that we are enabled to construct machines, build bridges and railroads. By the use of machines, bridges, and railroads other houses are built, other food, other clothing is prepared and distributed. To obtain houses, food, and clothing our effort is put forth. The medium which rewards us should assure us the possession of that for which we toil. As it is human effort that supplies human wants, and as human effort is known by its results, the medium of exchange and measure of value should be based directly upon the results of human effort; that is, effort of a certain quantity and quality, as evidenced by

its result, should be rewarded by that which, under the law of supply and demand, will assure the possession of the result of other human effort of a certain quantity and quality in an acceptable form. Human effort should be measured by human effort, not by any one commodity, however precious, the supply of which is inconstant; human effort should be rewarded by human effort, not by any one commodity, however precious, the value of which is unstable. The attainment of this end is the final step of that evolution which began with barter, and through the use of coin and paper representatives of coin we are taking that step so gradually that we notice not its meaning.

Obviously it must not be that the assurance of reward be based upon the result of human effort, as evidenced solely by any one commodity. Cloth, corn, leather, each varies in quantity from year to year, and the supply is not always in the same ratio to the demand—that is, neither one of these commodities is of a definite value that is permanent. This same objection applies, but in greater degree, to both gold and silver. The assurance of the reward of human effort must not be based solely upon the result of human effort as embodied in houses, mills, factories, railways, canals, ships, machinery, for these structures are not indestructible. Even those that endure for centuries may fluctuate in value as they increase or decrease in their capacity for service to society, because of change in the currents of the law of supply and demand, or as they are honestly and capably or dishonestly and incapably managed. As it is for the results of human effort in all their varied forms that the aggregate of human effort is put forth, its reward should be the assurance of a given measure of effort as embodied in desired results.

A paper currency, therefore, should be based directly upon the assurance of the result of human effort to make its value good unqualifiedly and unconditionally; and that it may attain the utmost confidence, such assurance must be universally known to be sufficient and reliable. This can only be when a group of people, the members of which, perceiving a secure currency to be vital to their prosperity, combine in giving that assurance. Such a group of people cohering by the force of common need, constituting a state or nation, can give assurance of their combined effort through enactment of their administrative body known as the government. The instrument whereby that enactment can be made good is the power of taxation, which is the power of the government to take from its people a portion of their effort for the attainment of ends necessary to their common good. The acceptance of such a currency among a people will depend in natural course upon the degree of their coherence as evidenced by their confidence in the honesty and ability of their own gov-

ernment to make the currency good, and also upon the knowledge of the values represented by the different representatives of value constituting the currency. Its acceptance among other peoples will depend also upon the facility with which it can be exchanged for currency in general use in their countries.

That a paper representative of value, resting upon the power of taxation, may attain a high degree of confidence, is evidenced by the United States bonds themselves, which are eagerly sought throughout Europe and America; and the national bank notes, which rest upon the same basis as the bonds, are readily accepted throughout the entire country. But there is a respect wherein the provision for currency, if limited to the issue of bank notes secured by Government bonds deposited by the issuing source, has been seriously defective. In every country, and especially in one covering so extensive a territory and with such varied resources as the United States, the processes of production and distribution do not proceed with evenness and regularity week by week, month by month, or year by year. In the spring, great quantities of fruit are shipped North from the semitropical lands of the South; in the autumn, innumerable train loads and vast cargoes of grain come from the Western plains to the Atlantic seaboard; the great mills and factories in every line of industry are busier at one time of the year than another. Currency in greater abundance is therefore needed at the times of greater activity than during the periods of comparative dullness. If there be sufficient national bank notes for the times of activity, there is during the times of dullness a plethora which is an incentive to overtrading and speculation. If their issue is only sufficient for the ordinary needs of exchange, there is a scarcity at the times of greater demand, with the result that exchange is hindered, the processes of industry retarded; that is, the currency provided by our present national bank note system is not elastic, and the restrictions imposed by the Government have made its issue so little profitable that the banks are often loath to increase the supply, which at the present amounts to but about two hundred millions of dollars.

The paper currency of the United States issued directly by the Government is composed principally of United States notes, the "legal-tender" legacies of the war, to the extent of $346,000,000, which, like the bonds, are based directly upon the power of taxation; certificates issued directly against and redeemable in silver to the amount of $345,000,000; Treasury notes issued against silver, but redeemable in either gold or silver, to the extent of $137,000,000; and certificates issued directly against and redeemable exclusively in gold to the extent of $45,000,000. The lack of elasticity is an objection to each of these issues of currency, and that they are open to other objections recent discussion has made

evident. Gold, the standard of value in international exchange, has for many years exceeded silver in value in greater ratio than that deemed by the United States to exist between them. As it has been the declared intention of the Government to keep all the paper currencies issued by it of the same value as though they had been issued against gold, its currency must be exchanged for gold upon the request of the holders. But as the legal tenders, when accepted in exchange for gold by congressional enactment, must be immediately paid out again, to be again exchanged for gold if the holders so request, and so on without limit, the supply of gold in the Government's possession has been kept at so low an ebb that it has often been feared that it would not be able to maintain its intention of keeping all its issues of currency as good as gold. To avert this fear, the Government has increased its indebtedness by several issues of bonds which have been exchanged for gold, which the legal tenders have immediately again begun to drain. It is obvious that this and other evils of the immediate situation must be removed. But, without further reference to them, this article must return to the discussion of an ideal system of note issue.

The experience of the United States, as referred to in the preceding paragraph, makes important in that discussion the reply to the question—

Should the paper representatives of value which serve as currency be issued directly by the Government?

The determination from time to time of the amount of currency necessary for a nation's exchanges at all places within the territory of that nation would require the services of a large number of intelligent men, thoroughly organized; and that the currency might expand and contract according to the nation's needs, a governmental mechanism would have to be provided that is difficult of conception, and its maintenance in efficiency would be more difficult. The losses occasioned by the errors of the officials would fall directly on the Government, and therefore entirely upon the whole people; and as the issue of currency in any event must be closely allied to the business of banking, if not always practically an incident thereof, the maintenance of a governmental organization for that purpose would impose a superfluous burden upon the people, as the banking organizations are capable of the same function.

As it is the banks that, by making loans and discounts and cashing checks, can the most readily get notes into circulation and can profit by so doing; as it is the banks that come directly into contact with the business pulse of entire communities, it is evidently proper that banks should be empowered to issue representatives of value for use as currency upon such resources as

would assure the value of such representatives of value, and under such checks and restrictions as would insure the expansion and contraction of issue in accordance with the law of supply and demand, not only in particular localities but throughout the nation. But as it is vital to the prosperity of the entire nation that its currency be incontestably and unquestionably secure, the guarantee of the whole people given through their Government should be the ultimate assurance of the security of their currency. The checks and restrictions upon its issue by banks should provide, therefore, that the liability for loss lie as far as possible with the banks, reducing to a minimum the responsibility, in any event, of the Government. To insure elasticity, these checks should be such as to necessitate the expansion and contraction of the currency in accordance with the law of supply and demand, by providing that, should there be insufficient currency, the banks would suffer loss, and that they also would suffer loss should there be an overabundance. The issue of currency by banks under governmental regulation and control should secure to the people the benefits that flow from competition reacting upon enterprise, and the benefits that come from the solidity of governmental backing. It should avoid the evils of overissue and speculative issue into which private enterprise is apt to be induced by greed and overcompetition, and the evils of that inertness which is characteristic of operations conducted entirely under bureaucratic control.

That such a system is not impossible of attainment, may be disclosed by an examination of different banking systems in force at different times and places, each of which has been characterized by one or more of the points of excellence which have just been specified.

Under the Scotch banking system, which has bravely stood the test of time, circulating notes are issued directly against the assurance of the forthcoming of human effort given by the drawers and indorsers of promissory notes. These promissory notes are paid with the results of the effort elicited by the circulating notes obtained in exchange for them. Although many of the old State banks are of unhappy memory, the Bank of Indiana and the banks of Louisiana were efficient in supplying currency for the commercial needs of their sections and are of honorable record.

An existing banking system of admirable performance is that of the Dominion of Canada. Under the Canadian banking act, adventurers and light-weight financiers are debarred from establishing banks by the fact that a charter is not issued for less than a capital of five hundred thousand dollars, of which at least two hundred and fifty thousand dollars must be paid up, and the character of the applicants is subjected to close scrutiny by the Minis-

ter of Finance. Notes are a first charge against all the assets of the issuing bank, and there is a penalty for excessive issue. The shareholders are liable for double the amount of their stock. There must be monthly returns to the Minister of Finance, and there is a rigid system of inspection. To insure the stability of the entire bank-note issue, each bank is required to keep on deposit with the Minister of Finance a sum equal to five per cent of its circulation, as a contribution to the Bank Circulation Redemption Fund, held by the Government to make good the notes of suspended banks. A most noteworthy and beneficent feature of the system is the practice of branch banking, the thirty-eight Canadian banks having four hundred and sixty offices. By their means the banking facilities of circulation, deposit, and discount are given not only to communities of considerable population, as in the United States, but even to hamlets remote from commercial centers. The competition of the different banks throughout their various branches, each striving for as large a proportion of the note circulation as possible, together with the governmental restrictions upon over-issue, insure to the millions of people inhabiting the Dominion a supply of currency, that at all times sufficient for their needs, expands and contracts as the demand for it rises and falls. The principle of branch banking places the available funds of the entire Dominion at the disposal of the communities needing them at the times of need, whereas in the United States, because of the narrow sphere of operation of each bank, there is frequently an overabundance of currency at one point, while the healthy exchange of effort is retarded at other points because of a deficiency.

The "Baltimore plan" proposed in 1894 by the American Bankers' Association, and the bill introduced by the present national administration in Congress in December, 1894, were in their essential characteristics substantially similar to the Canadian banking law, and it was the opinion then expressed of most competent financiers, that the adoption of such an act would have relieved the country of the most crying evils of the present system, and have provided the foundation for a most wholesome currency hereafter. It is noteworthy that the provisions of the Canadian act were largely the outcome of the recommendation of the leading bankers of Canada called in conference by the Canadian Government, while financial authorities, among the highest in the United States, found members of both Houses of Congress deaf to their recommendations during the discussion of the administration measure, which was finally defeated by the votes of demagogues subserving selfish interests. It, however, goes without saying, that the province of true statesmanship is often not to persist in seeking the immediate attainment of an ideal when it is unquestionable that opposition makes that immediate attainment

impossible, but to better existing conditions to the extent that betterment may be possible.

The steps that followed the defeat of the administration bill are well known. There have been additional issues of bonds which may serve as the basis for additional bank-note circulation under present laws. A better system will doubtless be adopted in time, but enlightenment as to the ultimate basis of representatives of value, and their use in forwarding civilization by effecting the exchange of human effort, will need to spread in great waves to the minds of many people before there is the adoption of an ideal monetary system, and before such a system will diminish the need for money changers by effecting exchanges of effort without their aid.

And it should be perceived that the adoption of a monetary system consisting of paper representatives of value, based upon the result of human effort, will be an important step toward the determination of an absolute standard or measure of value. The attempts to invest gold or silver, or both, with the attributes of such a standard are the underlying causes of a current phase of the monetary problem that is uppermost in discussion. To the word "bimetallism" many different meanings have been attached. But, as even the most pronounced advocates of the gold standard do not oppose the use of silver for subsidiary currency, the question evidently has not now to do with the abolishment of silver as money; and as the most pronounced advocates of silver at present, in demanding even the unlimited coinage of that metal, insist that its value always bears a definite and fixed ratio to the value of gold, the question evidently has not now to do with the maintenance of a double standard of value, for if the ratio between the metals can be constant, there necessarily is but a single standard. That neither silver nor gold throughout the past has afforded an absolute standard of value is abundantly shown by the frequent fluctuations in the value of these metals, both as compared one with the other and either with other commodities.

The ratio between the value of silver and gold that was fairly level from the beginning of the expansion of mediæval commerce to the middle of the sixteenth century, was violently disturbed by the great yield of the silver mines of Potosi. The instability increased with the variations in the supply of silver as mines were opened in Mexico, and in the supply of gold as that metal was found in Brazil. The disturbance became feverish with the discovery of gold in California, and the oscillations in the ratio have since that time not ceased, having been affected by the output of silver from the Western States, and apprehension is now being felt as to the effect of the development of new gold fields in Colorado, Siberia, South America, and Africa.

During the Christian era the ratio between the values of the two metals has varied from eleven to one to thirty-two to one, which is about the commercial ratio to-day. The question at the root of the present bimetallic controversy, therefore, is:

Can a definite ratio be preserved between the values of silver and gold, notwithstanding that under the law of supply and demand the ratio rises and falls?

There are those who think that such a definite ratio can be fixed and maintained by legislative enactment, either national or international, but the possibility of the maintenance of a fixed ratio is negatived by the history of at least five centuries. This is nowhere shown more clearly than in the valuable History of Currency, by W. A. Shaw; the verdict is "clear, crushing, and final"—that is, the purchasing power of a pound of gold or a pound of silver in the markets of the world is never a matter of certainty for any extended period. This is not alone because of the fluctuation in the value of other commodities, but also because of the unequal fluctuations in the value of these commodities themselves. The results that naturally follow these fluctuations legislation is powerless to change. Since 1890 the United States has been learning this fact through bitter experience. As stated on a previous page, the nation has incurred an indebtedness that will approximate three hundred millions of dollars in the effort to maintain the ratio of 15·98 to one.

It was long claimed by radical advocates of silver, that if the mints were open to the unrestricted coinage of that metal, as they are to the unrestricted coinage of gold, coins of the two metals would circulate together, and a double standard be thereby established. But it is clear that the silver coins would inevitably be accepted at their bullion value only. The effort of the national administration to maintain the parity of the two metals, which has been strained even under the restricted use of silver, would be broken by the deluge that its unrestricted use would bring. The four hundred and twelve and a half grains of silver that were worth one dollar in gold a generation ago would be worth but fifty cents in gold to-day. If four hundred and twelve and a half grains of silver were still molded and stamped as one dollar, gold dollars would be worth twice as much as silver dollars: there would be two separate and distinct standards of value. If, notwithstanding this, it should be the edict of Congress that dollars of the two metals should circulate side by side, it is evident that gold dollars would be hoarded, sent out of the country or melted, for no one would pay a gold dollar for an article that could be purchased with a silver dollar worth but half as much. The currency of the country would fall to the silver basis, and, as the bul-

lion price of silver is subject to great and continual fluctuation, all values would be uncertain, commerce would be restricted, manufacturing retarded. And it is obvious that the objections to the too extensive use of silver apply also to the use of paper representatives of value based upon silver.

But it must be recognized that the taking of such a step, disastrous as its total consequences would be, would not be absolutely without warrant of justice. Because of improved appliances and improved methods of production and distribution, the prices of nearly all the great staple products—clothing, shoes, furniture, grain, nails, tools, watches, drugs, glass, carpets—have in the last generation fallen in about the same degree that the price of silver has fallen. Therefore a silver dollar of four hundred and twelve and a half grains, taken at its bullion value to-day, will now buy about as much of the most needed results of human effort as a silver dollar of four hundred and twelve and a half grains thirty-five years ago, taken at its bullion value then, would buy of the most needed results of human effort at that time. Therefore a debt of one hundred dollars incurred thirty-five years ago, if paid to-day in gold, would inure to the creditor double the amount of benefit that the borrower obtained at the time the debt was incurred. Apply this reasoning to the indebtedness of the United States. It is claimed that, notwithstanding the great reduction in this debt since the war, the decrease in the prices of staple commodities, as measured by gold, has been so great that the amount of gold necessary to pay the present indebtedness would purchase at this time as much of the staple commodities as gold to the total of the indebtedness at the close of the war would have purchased at that time. That is, although the indebtedness of the Government, as expressed in gold dollars, has been vastly reduced, that indebtedness, as expressed by universally desired results of human effort, has not been reduced at all. In this connection it is significant that the depreciation in the price of silver has not led the people of Mexico to adopt other than the silver standard. Indeed, the depreciation has scarcely been noticed by them, largely because of the greater depreciation in the value of other commodities.

But as there are two sides to every question, so also are there two sides to every phase of every question. Wages, salaries, and incomes of all sorts, on the average, are far higher to-day than they were a generation ago. In many a pursuit it is easier for a man in a given time to earn two hundred dollars in gold to-day than it would have been for a man in the same pursuit to have earned one hundred dollars in gold then. So that the payment of a debt of one hundred dollars incurred then, in its gold equivalent now, would work no injustice to him. But this is not the

case in all pursuits. And does the application hold good with the United States bonds, whose holders in many cases have acquired them by inheritance and have throughout their lives made no contribution to that totality of effort from which is poured into their purses an annual interest that constantly increases in purchasing power? And the original holders of these bonds may have procured them by means of the revenue obtained from land that has appreciated in value through no possible effort or foresight of theirs. Do not all these considerations point to the fact that a standard of value which may measure justice to all and injustice to none must be based directly upon the results of human effort? It is not for an instant to be intimated that existing obligations shall be repudiated, nor can it be conceived that such an ideal standard will be attained save through slow and painful development. But the theoretical demonstration of such an ideal may even at this time not be beyond the bounds of possibility. And there may be all the more need for such demonstration because of the increase, both present and prospective, in the production of gold, which may at some future time cause the fluctuations in the value of that commodity to be no less than they have been in the value of silver.

But even the adoption of an ideal monetary system would not entirely deprive the precious metals of a positive monetary function. Until one such system were adopted by all of civilization, gold would be needed in international exchange; and for various reasons, perhaps, whether the basis for circulating notes were the assurance of the result of human effort as given in promissory notes, or whether it were stocks, bonds, or other securities depending for their value upon the result of human effort, it might now and then happen that the holders of the notes might want to make an immediate test of their value. The issuing source to preserve confidence in the notes emitted by it must be able to satisfy this test. As the medium of exchange that antedated notes and that has not been entirely superseded by the issue of notes is coin; as coin has a definite intrinsic value, which notes have not; as coin is durable, portable, and readily exchangeable—it follows that a natural and practical immediate test of a note's security is the readiness with which it may be exchanged for coin. To this end, when authority to issue notes has been given, it has usually been required that specie in a certain minimum ratio to the value of the note circulation be held by the issuing source for the redemption of notes presented for that purpose. The facility for the exchange of notes for coin may be not only a test of their security, but, as in the Dominion of Canada, a means whereby through the competition of various banks the note circulation may be contracted as need for it is lessened, each of the Canadian

banks being required to redeem daily such of its notes as are presented for that purpose.

And this last reference to the Canadian banking system gives rise again to the thought that perhaps, if there could yet be adopted in the United States a banking system modeled upon something of the same plan as that of Canada, it would give the nation more relief than could any other step that is now at all practicable in connection with monetary issue. Such a system would provide within safe limits the abundance of currency that the farmer and the laborer struggling for a livelihood in the West and Southwest are led by fallacious reasoning to believe can only be obtained by the free coinage of silver.

WHY PROGRESS IS BY LEAPS.

By GEORGE ILES.

AS master of electricity man is crowned the king of Nature. A brief glance at what electricity has done and promises to do may have interest in itself; it may have yet more in disclosing the law by which art and science march onward with ever-hastened pace, how it comes about that the history of modern progress is little else than a story of revolution. We shall see that the subjugation of electricity means for thought and work not an addition merely, but a multiplier. It marries the resources of the mechanic, the engineer, the chemist, the artist, with issue attested by all its own fertility, while it annexes province after province unimagined before its advent. Because the latest upward stride in knowledge and faculty has fallen to the lot of the electrician, he has broadened the scientific horizon vastly more than any earlier explorer; beyond any predecessor he has found more in the field wherewith to prove the fecundity that infallibly stamps every supremely great agent of discovery. As we trace a few of the unending interlacements of electrical science and art with other sciences and arts, we shall be reminded of a series of permutations where the newest of the factors, because newest, multiplies all the factors that went before by an unexampled leap.* We shall find reason to believe that this is not merely probable, but really is as a tendency true, and not alone of the

* Permutations of two elements, 1 and 2, are (1 × 2) two: 1, 2; 2, 1; or *a*, *b*; *b*, *a*. Of three elements the permutations are (1 × 2 × 3) six: 1, 2, 3; 1, 3, 2; 2, 1, 3; 2, 3, 1; 3, 1, 2; 3, 2, 1; or *a*, *b*, *c*; *a*, *c*, *b*; *b*, *a*, *c*; *b*, *c*, *a*; *c*, *a*, *b*; *c*, *b*, *a*. Of four elements the permutations are (1 × 2 × 3 × 4) twenty-four; of five elements, one hundred and twenty, and so on. A new element or permutator multiplies by an increasing figure all the permutations it finds.

gains which follow in the train of conquered electricity, but also with regard to every other signal victory which has brought man to his present pinnacle of power and insight. If in former advances this permutative principle has been undetected, it stands forth in clearest relief in that latest and therefore utmost stride of skill and interpretation ushered in by Franklin, Volta, and Faraday. And we shall presently note that this permutative tendency offers a key to some puzzling chapters in the biography of the creatures which man has far outstripped in the race of life, and may also shed a needed ray on the story of the planet where they and he have together struggled and vanquished or succumbed. If all this may be maintained, a permutative tendency can perhaps be suggested with respect to evolution in general as colorably as with regard to development in particular realms. Is this a large claim? To the evidence, then:

By way of preface, let us for a moment consider the achievement most worthy to be compared with the conquest of electricity, and, indeed, its necessary precursor.

When man first kindled fire, he rose to a new primacy among created beings. Long before that fateful day he must have noticed how the blaze of a tree riven by lightning could bring roots and herbs to refreshing palatability, or, as a far volcano welled forth its lava, how welcome the radiance in wintry air. What, he may have thought, if I can summon fire at my bidding instead of waiting upon heaven to let it fall or earth to belch it forth? How the wish came to fulfillment has been the subject of many an ingenious guess. The likeliest of them imagines that in striking a bit of quartz against a flint to point an arrow, a spark fell on dry tinder, and that what at first was accident was soon repeated by design. No piecemeal acquisition this, like learning to hit a mark with stone or bolt. The man barely able to light a fire was enormously advantaged as compared with his fellow, however dexterous, who just fell short of this skill. At once the fire-maker took a bound forward that decisively withdrew him from his next of kin. It was as if the globe had expanded itself beneath his tread; for now, no longer chained by the sunbeam, all the frozen north was added to his hunting ground. The burning brand cleared his path through the forest or shaped from a tree trunk his rude canoe. It lifted the dreary pall of night. His hearth, heaped with boughs, cheered with light as well as warmth, and became the family rallying place and altar. Baneful roots buried in its embers lost their poison and furnished a toothsome meal, while food of many kinds when roasted or seethed was improved in flavor and could be longer stored to abridge the seesaw between plenty and want. As the cook daubed clay on her roasting tray of twigs that it might the better withstand flame, she

soon learned that clay by itself was a capital material for oven, pot, or kettle, and Sèvres and Worcester, with all their varied art, here took their rise. As primitive fisherman and hunter, man employed fire to lure his prey, to affright the beasts to which he himself was prey, or to yield protecting smoke against insect pests scarcely less to be dreaded. In later ages as mariner he erected on storm-beaten coasts beacons whose carefully tended blaze gave warning or comfort to drifting voyagers, the flickering ray foretelling the sunlike beam of Sandy Hook or Skerryvore. As warrior he crowned the hills with similar flares to voice alarm to scattered allies, prefiguring every modern telegraph. Again, as warrior, having profited by the hardness fire conferred upon his wooden spear, he was to receive gifts yet greater. Where, as on the shores of Lake Superior, native copper almost pure lay upon the ground, it was laboriously pounded into the primitive knife or hammer. With fire his servant, the savage was independent of such rare finds. Wherever he came upon an earthy mass, glittering with however small a fraction of metal, he had but to bring the ore to his hearth to free copper or iron from its bondage. There and then the art of the founder began to take the place of the drudgery of the smith—a supersedure characteristic enough and one of an uncounted series where good has had to make way for better, where the worker and the fighter himself has been overcome by stronger thews and keener wits. No triumph of miner or chemist, of engineer on land or sea, that does not date from the memorable hour when a savage just a little cleverer than his fellows kindled for himself a blaze. Plainly, then, fire came among the resources of man as a permutator of exalted power. It gave an impulse to food-getting, to tool and weapon making, to building, to migration, to every art that cheered and adorned the home. It was an influence as pregnant as any that has made man human and brought the empire of Nature to his feet.

Through the course of all the ages since, almost down to our own day, flame had beside her a twin force all unrecognized. Elusive as a wood nymph she glinted as lightning, or as the aurora streamed fitfully across the sky. Anon she condescended to the amber of the sea beach, which under gentle friction drew to itself fragments of fallen leaves, of withered straw. In yet other guise she defied the downward tendency of unsupported masses, and, as the legend tells us, sorely puzzled a shepherd in bidding his crook cling fast to the ceiling of a cave roofed, as we would say now, with magnetic ore. At a later day the magnet became something more than an empty marvel, and as the compass assumed the office of guiding sun and star when these were hidden. Little wonder that so various a masquerade was long

impenetrable, that Franklin less than five generations ago should detect that lightning and electricity are one, and that only in our day at the hands of Hertz has it been demonstrated that the electric pulse differs only from the wave of heat or light in being longer. This discovery of Hertz was long ago foreshadowed in the observation that heat can have electric origin. One of the first fruits of electrical study was the finding that some metals transmit electricity better than others, and that the efficacy of a conductor depends in part on its size. When a conducting wire was reduced to extreme tenuity, the resistance to the current's passage, with striking resemblance to common friction, expressed itself as vivid heat. The miner and the gunner at once saw their opportunity to use electricity to touch off their fuses and to explode at the same instant, with an effect before impossible, a round of separate charges.

Copying the methods of the miner, the mechanic and the chemist very often find electric heat the most advantageous they can employ. When the broken blade of a propeller is to be repaired, the electric welder can be taken to its work instead of the work having to go to a stationary welder. When electric heat is carried into a crucible through almost impenetrable walls of gypsum, it enters the very heart of its task without the offense and waste of flame. Thus to-day is flame face to face with a supplanter in the shape of its long undetected twin. Until this generation flame alone was the source not only of heat, but of the beam of candle, lamp, and gas jet. To-day myriads of electric bulbs are aglow without flame—indeed, just because combustion is rendered impossible by the rigid exclusion of air. As these incandescent lamps were long ago prophesied in the miner's electric fuse, so also has the first simple process of the electroplater led up to an art incomparably more important. To-day not surfaces merely, but large masses, chiefly of statuary, are built in cool tanks by electricity. Let the current become cheaper still, and the founder may find the remainder of his business transferred to this formidable rival, the warping heats of sand molds banished, the scorching temperature of crucible and ladle a reminiscence. The same fate may be in store for the smelting furnace. Already vast quantities of copper are refined electrolytically, and an auspicious beginning has been made in using electricity for the whole process of parting metal from ore. Thus methods which commenced in dismissing flame end boldly by eliminating heat itself. This usurping electricity, it may be said, usually finds its source, after all, in fire under a steam boiler. True, but mark the harnessing of Niagara, of the Lachine Rapids near Montreal, of a thousand streams elsewhere. In the years of the near future motive power of Nature's giving is to be wasted less and less, and per-

force will more and more exclude heat from the chain of transformations which issue in the locomotive's flight, in the whirl of factory and mill; and thus in some degree is allayed the fear, never well grounded, that when the coal fields of the world are spent, civilization must collapse. As the electrician hears this foreboding, he recalls how much fuel is wasted in converting heat into electricity. He looks beyond either turbine or shaft turned by wind or tide, and, remembering that the zinc dissolved in his battery yields at his will its full content of energy, either as heat or electricity, he asks, Why may not coal and forest tree, which are but other kinds of fuel, be made to do the same?

In another field let us observe electricity as a factor of fruitfulness quite as singular. It was at first the chemist who emancipated electricity for new and myriad uses. His successor to-day is the engineer, who wins his spurs by bringing his generator to practical perfection, by improving his steam and gas engines to double their efficiency of thirty years ago. If to the engineer and mechanic the electric art owes much, magnificently has the debt been repaid. As we discover in replacing at our street door an old-fashioned moving bell pull by an electric wire armed with a push button, electricity transmits motion without movement of its conductor as a mass. Availing himself of this golden property, the machinist removes from his shop a labyrinth of wheels and belts and puts in their stead a few wires at rest, each in charge of the motor actuating a machine. Manifold gains result. The power needed to whirl these wheels and belts is saved, and when but one or two machines of a large number are to be set in motion the economy rises to a high figure, while the workshop is lighter, cleaner, more wholesome in every way. Since electricity is of all phases of energy the easiest to preserve from losses resembling leakage or friction, the current can not only be distributed throughout the largest workshop with convenience and economy, it can be sent to the shop from an engine or a water wheel many miles away, as in connecting motors at Buffalo to dynamos at Niagara, twenty-seven miles distant. With the transmission of electricity for distances vastly exceeding twenty-seven miles we have long been familiar in the telegraph. It is by improving the coverings which prevent the current escaping from its wire, by taking advantage of the fact that a wire can almost as well carry a current of high tension as of low, and, above all, by increasing the quantity of the current so as to make the enterprise worth while, that the telegraphy of power has followed upon the telegraphy of mere signals.

In the telegraph at work over long distances a remarkable peculiarity of electricity displays itself. In days of yore, when letters were intrusted to a chain of messengers, each of whom bore

the pouch for a stage of its journey, a carrier might come to the end of his trip utterly fagged out; but if he had barely the strength to pass his burden to the next man it was enough. Much the same is the system of relays when a telegram takes its way from New York to Tacoma. First it goes to Buffalo, where the current, faint after its run of four hundred and forty miles, touches off a second powerful current born in Buffalo. This in its turn bears the dispatch to Chicago. There a third current is impressed into service, and so on, until at the end of a succession of transfers the words are clicked out in Tacoma. This whole process is committed to self-acting repeaters that do their work in the fraction of a second. It is in pulling triggers in such fashion as this, in liberating forces indefinitely greater than the initial impulse, that electricity brings to muscles of brass and steel something very like a nervous system, so that the merest touch directs the course of a steamship through the tempest-tossed Atlantic. Engineer, workman, and artist can thus reserve their strength for tasks more profitable than muscular dead lift and find their sweep of initiation and control broadened to the utmost bound. In the field of war, for instance, a torpedo can be launched, propelled, steered, and exploded by a telegraph key a mile or two away; the constructor may, indeed, confidently give all his orders in advance and build a torpedo which will fulfill a fate of both murder and suicide predestined in its cams and magnets. Or a camera, under the control of an operator at the safe end of a wire, is sent soaring in a balloon car above an enemy's camp, effectively playing the spy.

Another apparatus electric and photographic, happily less uncommon, is employed for observatory records which, as near Arequipa, in Peru, without supervision keeps itself busy for a fortnight together. Still more remarkable is Mr. Muybridge's round of cameras, timed as only electricity can time them, which seize practically instantaneous views of figures in rapid motion, as horses trotting. In Mr. Edison's kinetoscope photographs made at each forty-sixth of a second follow one another so quickly under an eyepiece as to fuse with the effect of life and action. Pictures of birds thus caught on the wing may prove seed corn for harvests to be reaped by the experimenter in mechanical flight—an achievement which, strange to say, attracts the interest of military rather than business men. In the service of war and peace one would suppose the ordinary telegraph to be speedy enough. Not so, thinks the inventor. In the latest process a dispatch wings its way from New York to Chicago at the rate of one thousand words a minute, to Philadelphia thrice as fast. The telegram is taken first to a machine which symbolizes each letter as perforations on a strip of paper; then the strip is run between

metallic springs of exquisite delicacy. At each perforation the springs touch and the current takes its way through the wire. At the receiving station the delay involved in the arousal and action of electro-magnets is abolished. The current instant by instant writes its message on a moving ribbon of paper sensitized so as to change color under an electric flow. This instance is typical of what ingenuity can do when electricity is added to its armory. A task is divided between an operator and an automatic machine in such wise that intelligence is allotted only that part for which intelligence is required, while for the remaining part the utmost speed of electrical and chemical action is invoked—a pace which in this particular case sixtyfold outstrips the most dexterous manipulation.

Another means by which inventors have expedited telegraphy has been by transmitting several messages simultaneously over a single wire. Of these multiplex systems certain are synchronous in principle and seem to have suggested to Prof. Elisha Gray his telautograph, an instrument that imitates exactly the motion of a pencil, in say Boston, by the motion of another, in say Baltimore, reproducing with equal facility either handwriting or outline drawing. To understand the principle involved, let us glance at an everyday application of electricity in keeping scores of clock pendulums, no matter how far apart, in perfect step. If two pendulums at right angles to each other are attached to a moving pencil their motions may be communicated to a distance by two currents which actuate two pendulums in control of a second and copying pencil. The electric clock at which we have just been looking can, if we please, be sealed in a glazed box, secure from dust and dampness. Here opens a fresh path to the inventor who wishes to avoid the resistance or leakage entailed when a rod moves through a slot or a stuffing box. It is often of cardinal importance that a bit of metal at rest should throb with a pulse strong enough to do severe drudgery or tell a tale which otherwise would go untold. If an engineer wishes to know how much heat wastes itself through the walls of a steam cylinder, his question is answered through a motionless wire attached to a delicate metallic thermometer buried in the cylinder's mass. In experimenting with new alloys the same method informs the chemist of changes of temperature at the core of his crucible, changes often abrupt and transient and at times denoting qualities he seeks to detain or reproduce. In a very different domain of exploration the engineer uses the telephone to expose perilous defects in metal beams.

As we prove when we unhook a telephone, or lift an incandescent lamp, electricity readily traverses a flexible wire: this unbars a fresh resource to invention. To-day rock drills, coal cut-

ters, and deck planers are designed in forms which combine motor and tool; so much is thereby gained in adaptability that a remodeling is in progress of much light machinery in its first estate rigidly limited in play by shafts, belts, or gearing. Dentistry and other arts of refined manipulation are indebted for novel facilities to the flexible mechanical shaft—a tightly wound coil of steel wire. This device is in turn being shown to the door by the new partnership between an electric thread and a tool. And the wire, however slender, which binds a reservoir of power to its work, can on occasion be discarded, as in the rolling contact of the electric trolley wheel. And even contact can be dispensed with if strict economy is not imperative. We are familiar with the annoyance, due to induction, of being obliged in a telephone circuit to overhear other subscribers, whose wires are often far distant from our own. A hint in this for the engineer at the head of the British telegraphs, Mr. Preece. Utilizing induction, he has established a telegraph between Oban and Auchnacraig, divided by six miles of sea, using wires strung along the opposite shores.

Electricity, light, heat, and chemical action are all in essence motion; electricity is the most desirable of them all, because it can most readily and fully become the source or issue of any other. The pre-eminent sensitiveness of electrical apparatus makes it a surpassing means of measuring minute portions of space or time, of light, heat, chemical activity, or mechanical motion. Hence a brood of telltales of widely contrasted purpose. Selenium, a metalloid of the same lineage as sulphur, and betraying its descent by a striking family resemblance, has the curious property of transmitting electricity more freely in light than in darkness; a stick of selenium, therefore, is the pivot of a device to give warning when extinction befalls a lamp charged with important duty. In thermometers a circuit broken or completed acts as a fire signal, or, on shipboard, heralds the approach of an iceberg. Electric fingers sound a gong when the water recedes below the safety level in a steam boiler, or report an attempted breach of bolt or bar by the burglar's jimmy. Each of these warnings can be registered at a distance, so that in case of neglect by an attendant there can be no disputing the fact. Now, if an electric alarm can summon a servant to duty, why may not the inventor go further, and so add to his device that it shall of its own motion do what needs to be done? Accordingly, we find furnaces fitted up with electrical control, so that the draft is opened or fuel added when the temperature falls too low, or the reverse, when the flame is too fierce; when the fuel is gas this stoking leaves nothing to be desired. New mechanism of this kind is constantly being contrived. The inventor who began by conferring electric nerves on muscles of brass and iron has,

thanks to electricity, gone the length of combining his wires and magnets into something very like a conscious and responsive brain: his intelligence culminates in duplicating itself.

Prodigal as electricity is of gifts to the mechanic and engineer, it as generously multiplies the resources of their friend and partner, the chemist. Electricity, we must not forget, was presented to the world as a stream of tolerably even flow, by a process of chemical undoing, in Volta's crown of cups. If chemical taking apart can yield a current, a current can in turn be used to build, as every piece of plating proves. Yet to construct a battery in which both processes shall alternate, without undue weight or waste of material, is a task as yet not satisfactorily accomplished, despite constant and ingenious attack. A thoroughly good and simple storage battery would mean nearly as much for electric art as the dynamo. From a dynamo it would receive currents derived from wind or water powers, or from engines temporarily laden below their capacity, and use these currents to restore a metal from its solution by a process exactly that of electroplating. Then, on demand, it would yield electricity once more by surrendering this metal to solution, as a common voltaic battery does. If the chemist has thus far been somewhat baffled by the problems of the storage battery, he has had better fortune in other fields of endeavor. Electricity joined to heat hands him a two-edged sword of irresistible cleaving power. Compounds, such as those of chromium, of peculiar refractoriness, are readily parted in the electric furnace of Moissan, and elements once extremely rare are now marketed in quantity at prices steadily falling. A generation ago aluminum was so scarce and dear that it was formed into jewelry; to-day the metal has been so cheapened by electricity that it finds a ready sale as kitchen ware. Minute diamonds and rubies of electric manufacture are now competing with the product of the mine, and materials used on a gigantic scale in the arts—caustic soda, bleaching powder, and the like—are produced at less cost than ever by electrical agency. The chemist, when he chooses, can beat his electrical sword into a trowel, and build compounds which seem prophetic of the day when the slow elaborations of the farm and orchard shall make way for the artificial synthesis of sugars, oils, and starch.

Greater than all the wealth created by electricity in workshop or laboratory are its aids to pure research. The chief physical generalization of our time, the persistence of force, came into view only when electricity was recognized as a phase of energy, only when electrical means of measurement had become trustworthy. It is because men of absolutely disinterested spirit, like Faraday and Henry, devoted themselves to ascertaining the laws of electricity that we have to-day the telegraph, the telephone, and

the electric furnace. "Before there can be applied science there must be science to apply," and it is in enabling the investigator to know Nature under a fresh aspect that electricity rises to its highest office. As a case in point, take the bolometer of Prof. S. P. Langley: its delicate wire, sensitive to one millionth of a degree centigrade, is moved by minute steps through the invisible areas of the solar spectrum; each indication of temperature, automatically photographed, comes out in a series of dark and bright lines. This process, repeated with each chemical element, promises that one day the physicist will have before him a full or tolerably complete map of every distinctive spectrum. He can then ask, Given such and such vibrations, how is the body constituted that sent them forth?—much as a musician might try to reason from the tone and timbre of a note to the structure of the instrument which uttered the note. In further uses of photography the physicist, by means of instantaneous contacts, is beginning to find out what goes on in the critical moments when chemical collisions in the voltaic cell are gliding into electric waves—an inquiry which bears on the prime question of electric art, namely, how the chemical energy contained in coal can be transformed into a current without the enormous levies imposed by the steam engine. Hertz, in the purely scientific excursion by which he generated electric waves intermediate in length between those of sound and light, came upon a discovery of profound interest—that, given its appropriate ray, every substance whatever offers it a free and open path. It remained for Prof. Röntgen to complete the proof that certain of these rays, while refusing obedience to the laws of light, can, nevertheless, exert photographic power. His apparatus combines in the happiest way the utmost resources of both the electrician and the photographer; at a vital point it employs the singular capacity for fluorescence whereby the compounds of barium and other substances can convert to visibility an otherwise invisible image. Apart from such a triumph as this, rich in possibilities for art and science, the common routine of ascertaining electrical constants has high value in research; to know the conductivity, polarizability, and other electrical properties of matter is to peer at its architecture through new windows; to detect many of the links which bind atom to atom, molecule to molecule. A new orchestration of inquiry is possible through the instruments created by the electrician, through the advances in method which these instruments suggest. Hence to-day a surround is in progress which may early in the twentieth century make atom and molecule as obedient to the chemist as brick and stone are to the builder now.

But, however much new knowledge may do with electricity, some of its best work is already done. It is not likely in the fu-

ture to perform a greater feat than placing all mankind within earshot of each other. Were electricity unmastered, there could be no democratic government of the United States. To-day the drama of national affairs is more directly in the view of every American citizen than a century ago the public business of Delaware could be to the men of that little State. Railroads, with all they mean for civilization, could not have been born without the telegraph; and railroads and telegraphs are the sinews and nerves of national life, the prime agencies in welding together the diverse and widely separated States and Territories of the Union. A Boston merchant builds a cotton mill in Georgia; an Illinois manufacturer establishes an agency in Seattle; the telegraph, which informs them day by day how their investments prosper, tells idle men where they can find work, where work can seek idle men. Chicago is laid in ashes, Charleston topples in earthquake, Johnstown is whelmed in flood, and instantly a continent rises to their relief. And benefits denied to charity issue in the strictly commercial services of the telegraph. Its click has exorcised the fiend of famine from every quarter of the civilized globe; for, with its finger on the throttle-valves of locomotive and steamship, no longer does food rot here when thousands lack bread there; the markets of the world are merged, and that one great market reaches every man's door.

In a less conspicuous way electricity works equal good. Its motor, freeing us from the horse's deliberate pace, is spreading out our towns and cities into their adjoining country; field and garden compete with narrow streets; the sunny cottage is in rivalry with the odious tenement house. Electric lines, at first suburban, are now fast linking town to town and city to city, while as auxiliaries to steam railroads they place sparsely settled districts in the arterial current of the world. Great as are the blessings which electricity brings to country folk, it stands ready to bestow yet more in the hives of population. Until a few decades ago the water supply of cities was drawn in part from wells here and there, from lines of piping laid in favored areas, and always insufficient. To-day a supply such as that of New York is abundant and cheap because it enters every house. Let a single electrical service enjoy a like privilege, and it can offer a current which is heat, light, chemical energy, or motive power at a wage lower than that of any other servant. Unwittingly, then, the electrical engineer is a political reformer of high degree. All that he asks is that this municipal electricity shall be under control at once competent and honest. Let us hope that his plea, joined to others as weighty, may quicken the spirit of civic righteousness so that some of the richest fruits ever borne in the garden of art and science may not be proffered in vain.

This rapid survey of what electricity has done and yet may do has shown it the creator of a thousand material resources: the corner stone of physical generalization; a stimulus to the moral sense, by making what otherwise were an empty wish rise to sympathy fulfilled; while, in more closely binding up the good of the bee with the welfare of the hive, it is an educator and confirmer of every social bond. Are we not, then, justified in holding electricity to be a multiplier of faculty and insight, a means of dignifying mind and soul, unexampled since man first kindled fire and rejoiced?

And the advances due to electricity have significance still unexhausted. It was in 1800, on the threshold of the nineteenth century, that Volta devised the first battery—the crown of cups. In less than a hundred years the force then liberated has vitally interwoven itself with every art and science, with fruitage not to be imagined even by men of the stature of Watt, Lavoisier, or Humboldt. Compare this rapidity of conquest with the slow adaptation, through age after age, of fire to cooking, smelting, tempering. Yet it was partly because the use of fire had drawn out man's intelligence that he was ready so quickly to seize upon electricity and subdue it. The principle of permutation, illustrated in both victories, interprets not only the vast expansion of human empire won by a new weapon of prime power, it explains also why these accessions are brought under rule with ever-accelerated pace. Every new talent but clears the way for the talents newer still which are born from it.

And a fresh mode of mastery entails other consequences well worthy of remark. Suppose two contending armies face each other, fairly matched, except that one has the telegraph and the other has not. Which will win? In less striking fashion, but still decisively, must every factor of prime rank as it made its appearance have told in the battles of early man. Let us turn from discovery and invention to some consideration of the primitive discoverer and inventor, and try to recall the epoch when his inarticulate cries were becoming the rudiments of speech. Let us imagine him a hunter returning to his fellows from a solitary expedition. He tells that he saw a deer quench its thirst at a brookside, but found the animal too fleet for his arrow; how he heard in the distance a bear's fierce growl, and fortunately came upon a cave where he took refuge till the brute had passed. Such a faculty of communication as this, even in its beginnings, would give a tribe enjoying it an incalculable advantage over its unspeaking kin. Speech makes the distant as if present in space, makes the past as if present in time; it is the first and most signal step, therefore, by which man conquers both space and time. No elephant or dog, however intelligent, has means to tell

what he saw here an hour ago, or what is to be found there beyond the range of the eye. Because in early times speech thus placed the experience of one man at the service of other men, the possessors of this matchless power could, if they chose, exert deadly rivalry against their mute next of kin, and either annihilate them, or banish them to sterile wilds, or degrade them to servitude. What is probable here is probable in other fields of struggle, and we have a hint as to why connecting links in the plexus of organic life are either very rare or wholly lacking. The introduction of a radically new weapon, or tool, would so redouble the strength of the creature able to grasp and wield it that its war on competitors would end so soon as to leave scarcely a relic on the field.

Speech led to another great achievement when it called to its aid the carved or painted symbol, the word-picture, and at last the alphabet. Then the recorder, the priest, the teacher, was no longer a mere speaker who had to be present when he told his story. Ages after his death, his annals, prophecies, parables, remained to be read, to echo his voice—and this perhaps on shores many leagues remote from the penman's home or grave. Knowledge could now be accumulated as never before, for every man could begin where the experience of his predecessors had left off. The culmination of this mighty art issues to-day in two wonderful instruments—the phonograph, which bids the spoken word record and repeat itself with all its characteristic tones; the camera, which instantly limns all the eye can see and more, which prints much that the tongue and the pen must leave unsaid. In a masterly discussion of the origin of languages and the antiquity of speaking man, Mr. Horatio Hale concludes that the acquirement of speech dates back but eight to ten thousand years. He credits speech and writing with the sudden and wonderful flowering of human genius which developed in Egypt, Mesopotamia, Phœnicia, Northern India, and China a high and varied civilization, whose memorials, in their works of art and literature, astonish us at this day, and in some respects defy imitation.*

To paint and to write implies a free and supple hand; gesture, upon which philologists are substantially agreed that primitive speech largely depended, requires the like freedom of hand and arm. Hence, before man could paint, or write, or even gesticulate, it was necessary that he should be erect. Man's assumption of the upright attitude marks one of the supreme stages of his progress. What have since become arms and hands, relieved from tasks of locomotion, were able to come into contact with

* Proceedings of the American Association for the Advancement of Science, Buffalo, 1886, p. 315.

things and know them more fully and exactly than ever before. The brain, informed and stimulated by its new harvest of impressions, imagined fresh feats of skill and directed them. The rude stone, lifted from the ground and used as a hammer, was gradually shaped as an axe, a scraper, a chisel, an arrowhead. There lay the germ of the ingenuity which blossoms to-day in the locomotive and steamship, in the observatory camera which multiplies the known universe a thousand times, which in the telephone catches the echo of storms sweeping the solar disk. As with the faculty of speech, so doubtless also when the hand began to handle and to tell the brain what it could feel and do. A gain so pregnant as dexterity, even in its feeble inception, would come as an irresistible wedge between the fighters and the workers who had it and their fellows who missed it by however little.

The permutative tendency which we are tracing has dug other gulfs than those which part man and anthropoid. Let us glance for a moment at creatures far beneath mankind in the scale of being. Birds are clearly derived from reptiles, but how far apart to-day are the bird and the reptile! It was the power of flight, with all that it involved in transforming every organ of the body, in revolutionizing habit, that stood at the parting of the ways. Even in its beginnings this power would promote escape from enemies, the procuring food in places otherwise inaccessible. In the process of natural selection here would be the faculty valuable beyond any other, and therefore first seized in its favoring variations. Flight beyond any other capacity would thus be developed and increased as one generation succeeded another, until at last the flier could disregard its unwinged enemies, seek food on steepest crag or farthest islet, and there lay its eggs and nurse its brood with none to make it afraid. As far as the fossil record has been pieced together, it amply warrants this view of the early history of the avian race.

Take passage now to a widely different realm and note the permutative effect wrought when insects supplant the winds at the business of fertilizing flowers. Nectar secreted near the pollen of a plant attracts flies and moths brushed by this pollen; they sail away to other flowers and tie a marriage knot with an effectiveness impossible to the aimless air. The consequence is that simply through such woolliness of vesture as enables them to catch dust on their clothes, insects of narrowest intelligence are unknowingly the painters, sculptors, and perfumers of unnumbered varieties of blossoms. And indefinitely prior to either flower or reptile was the day when the earth, a fiery cloud, had come to the critical point, in its gradual loss of heat, where atom stood almost within the attractive range of atom, when the latent combinability of matter we call chemical was ready to be born. Was not the

releasing touch of cold a permutator of highest degree? It made every other possible, it forged the first link in the chain of forces, vital, mental, moral, in the life of earth and man.

What is here indicated in outline was suggested by the writer in the Popular Science Monthly for June, 1876. He has since gathered from men of mark in diverse walks of science data from which inferences such as those here set forth may be deduced in ample detail. These data he expects in due time to offer to the public, together with consideration of the facts which mask or qualify the permutative principle in evolution—a principle which accounts for the leaps of progress, human and general, for the accelerations of that progress, and for there being chapters missing in its story.

POSTHYPNOTIC AND CRIMINAL SUGGESTION.

By Prof. WILLIAM ROMAINE NEWBOLD.

IN my two preceding articles (March and April numbers) I have discussed what may be termed categorical suggestions and other closely related topics. I shall now take up certain other forms of suggestion.

From the conception of suggestibility it follows that any mental state, however initiated, tends to produce certain results. The most familiar method of initiation is through the instrumentality of language, but there are other methods. What is known as waxlike catalepsy, for example (*flexibilitas cerea*), is merely a form of suggestibility to motor impressions. When I take the arm of a cataleptic patient and bend it into a given position it remains fixed where I put it. In bending it I produce certain sensations, approximately those of a movement; among the possible results of such sensations is the production of the movement in question, and in the patient's disordinated condition this is the only apparent and perhaps the only actual result. It is also true that a pseudo-catalepsy may be found in less complete forms of disordination, in which the movement which I impress upon the arm is felt by the drowsy upper consciousness and accepted as indicative of a command. I saw some years ago a very curious illustration of an analogous motor suggestion in the case of a man who was subject to hystero-epileptic convulsions. Dr. B—— had hypnotized him standing; he then fell backward, and we allowed him to recline with his heels on the floor and his back flat upon the bed. This brought him into a very uncomfortable position, in which his head was bent backward toward his heels. He at once began to show signs of a convulsion, and, in spite of our imperative suggestions to keep quiet, grew worse every second. Then it oc-

curred to me that the attitude in which he was lying was one of the stages through which the patient regularly passes in the course of the hystero-epileptic convulsion—it is known as the opisthotonic position—and that the convulsion might be due to the tactile-motor suggestion given by the feeling of the attitude. As soon as we put him in a sitting posture the symptoms of convulsion disappeared.

The mode in which the suggestion is initiated is not essential to the theory, but it is often important in practice. Commands are usually realized more readily than mere suggestions, but the latter are sometimes the more efficacious. In general, the phenomena differ in degree only and not in kind from those of normal life, and just as a categorical suggestion may be realized at once, so may a hypothetical suggestion be realized under the circumstances indicated by the operator. Most of the illustrations which I have been using belonged to the former type; to the latter belong the still more curious phenomena of deferred and posthypnotic suggestion.

Simple deferred suggestions executed during the state of heightened suggestibility may be dismissed with a mere mention. The really interesting cases are those in which the execution of the suggestion given during a suggestible condition is deferred until the patient has returned to the normal state. As the phenomena have been studied chiefly in hypnotic states, artificially produced deferred suggestions of this kind are termed posthypnotic suggestions.

Analogous phenomena are found, however, as we would expect, under other circumstances. We are familiar, for example, with the effect sometimes wrought by dreams upon the waking life of the succeeding day. A happy mood or its reverse can often be traced to the effect of some vivid dream, and doubtless many of the mornings on which we "get out of bed on the wrong side" have been preceded by nights filled with disagreeable but forgotten dreams. M——, of whom I have before spoken, has given me an excellent illustration of the possible after-effect of a forgotten dream. He once told me that he had been for some months tormented by an apparition. He would wake in the middle of the night to find a hideous man beside him. The man held in his hand a knife, looked at him threateningly, then slowly moved backward, and, when at a considerable distance, vanished. Occasionally he saw in the place of the man a young woman with a black shawl wrapped about her head. He knew that these figures were unreal and had no belief in ghosts, yet they always left him terrified and suffering from nervous shock. I questioned him closely, but could get no clew to their origin. He had never had a dream in which they figured, and had never heard any story that

could have suggested them, save that he had heard when a child of a young woman having been strangled by her lover on the site of his father's barn, out in the country. There was no knife in that case, however, and he was sure it could have nothing to do with the apparitions. I then hypnotized him, and he at once told me the whole story. I had to question him somewhat, but I was keenly alive to the danger of asking leading questions, and am convinced that the story was told spontaneously. The girl had had her throat cut, he said; a coachman had claimed to have seen her ghost in the barn and had told him of it. After that, four or five coachmen in succession declared they had seen the ghost, and left the employ of M——'s father rather than sleep in the barn. M—— was greatly frightened and began dreaming about it. After the lapse of some years the dreams ceased, but about two years ago they began again. *He never saw the apparition*, he said, *except when he had been dreaming about the murder*. I told him he would never have such a dream again and would never see the ghosts. That was in August last, and in November he told me he had had no recurrence. I have not seen him recently. Another most interesting fact in this case was that, although M—— had totally forgotten all this in his waking state before being hypnotized, and although after being awakened he had not the slightest recollection of anything that passed while he was hypnotized, he did then remember most of the facts he had just been talking of and told me them again, expressing surprise that he could not do it when I first asked him.

Now, here we have a true posthypnotic phenomenon. It is precisely parallel to those cases in which the hypnotized patient is told that at a certain time and place, while awake, he will see John Smith, who will say this or that to him; the time comes; a phantom John Smith walks into the room and does what is expected of him. But the state which in M——'s case survived the shock of waking was not a suggested state in the common sense, nor was it revived upon the occurrence of some appointed condition or signal. The story is of interest as showing how purely arbitrary is the line which some writers would draw between the "normal" and "abnormal" in this field.

There are three especially interesting problems connected with posthypnotic suggestion: 1. What is the relation of the suggestion to the signal? 2. In what form does the suggestion exist between the time of awaking, when it is usually unknown to the upper consciousness, and the moment of execution? 3. What is its relation to the upper consciousness in which it reappears?

To the first of these questions no very clear answer can be given. We can say that the suggestion is "associated" with the signal, and it of course is, but that does not explain to my mind

the reason why this dynamic state remains inactive until the signal sets it in operation. In some few cases, when a sensory signal is to call a posthypnotic hallucination into the upper consciousness, we can conceive of the sensory stimulus as the spark necessary to explode the stored-up energy of the cells and raise the idea to sensory level—make a thought seem vivid, intense, and external like a perception. But this conception is of limited application. The signal need not be sensory at all. It may even be a process of the higher orders, such as a perception of resemblance or difference, or even may consist in the lapse of time. I gave T—— some numbers to multiply and told him that if the figures 1 and 4 happened to stand side by side in the course of his work he would tear the whole up. When the numbers appeared in that relation he at once noted it and carefully tore the paper to tiny fragments. It is not easy to conceive of the suggestion as held in check by the mere lack of such a complex process of reasoning as this. Such difficulties I can not, I confess, explain away, and as long as they remain unexplained, the theory with which they are connected can not be accepted as final. It is to avoid them that some writers have introduced the conception of a subconscious personality which hears, remembers, and obeys without reference to the condition of the upper consciousness, and this brings me to the second question.

We usually conceive of our potential memories as existing in the form of a functional predisposition on the part of the nervous mechanism, and as having no actual mental existence while we are not thinking of them. At the first glance one would suppose that the posthypnotic suggestion exists in the same form. But cases have been reported which seem to prove that sometimes at least the posthypnotic suggestion enjoys an actual existence, even while the upper consciousness knows nothing of it. Thus Mr. Gurney says of P——ll, one of his patients: "He was told on March 26th that on the one hundred and twenty-third day from then he was to put a blank sheet of paper in an envelope and send it to a friend of mine whose name and residence he knew but whom he had never seen. The subject was not referred to again until April 18th, when he was hypnotized and asked whether he remembered anything in connection with this gentleman. He at once repeated the order and said: 'This is the twenty-third day; a hundred more.' S——. 'How do you know? Have you noted each day?' P——ll. 'No, it seems natural.' S——. 'Have you thought of it often?' P——ll. 'It generally strikes me in the morning early. Something seems to say to me, You've got to count.' S——. 'Does that happen every day?' P——ll. 'No, not every day, perhaps more like every other day. It goes from my mind; I never think of it during the day. I only know it's got to be done.'"

Here it is conceivable that the counting was merely forgotten and not strictly subconscious; but sometimes the suggestion can be elicited by automatic writing while the upper consciousness is apparently quite normal and entirely unaware of what is written. At other times the subconscious state seems to effect partial union with the upper consciousness. Thus P——ll was told "The baking trade is failing." Next day while awake he put his hand upon the planchette and the instrument slowly produced the words "The baking trade is failing." While the writing was proceeding he said that some one seemed to be "hallooing in his ear something, he could not make out what, about the baking trade." Another of Mr. Gurney's patients, when told to see his wife, thought he saw a face in an air ball. It was dim and soon faded away. Later, the suggestion having been repeated, he said he "saw a lot of faces floating before his eyes" that night. Such cases are precious as throwing light upon the origin of the "spirit voices" and "visions" which many automatists hear and see.

Mr. Gurney also got interesting evidence of subconscious time reckoning. The patient, W——s, was "told in trance on March 19th that, when he came next, he was to poke the fire six minutes after his arrival, and that when he wrote he was to record the number of minutes that had run. On March 21st he arrived at 6.57½, and I set him down to the planchette in about a minute. The writing, which it took about a minute to produce, was '2, —3½ more.' . . . He was told on March 23d that a quarter of an hour after his next arrival he was to open and shut the door of the room and note the course of time as usual. The next time he arrived at 7.6½. He was set to the planchette at 7.19. The writing, produced at once, was '13 minutes and 2 more.'" At 7.22 he executed the suggestion.

Analogous phenomena in normal life are familiar. Many persons, of whom I am one, by giving themselves a suggestion upon going to bed to wake at a given time next morning, can make themselves wake at or about the time appointed. When the time is fixed by habit there is still more striking evidence of subconscious processes. For several months it was my practice to get up at 6.50 every morning. Not only did I usually wake about that time, but I would also often, after lying awake for some time, get out of bed suddenly without any clear intention of doing so or thought of the time. While busily thinking of something else I would suddenly find myself out of bed and beginning to dress; then, looking at my watch, I would find it was within a few minutes of 6.50. There was no striking clock within my hearing or other means of consciously reckoning time, as also there was not n these experiments of Mr. Gurney's.

It is upon such phenomena that the doctrine of subconscious

mental states rests, and to my mind the evidence for their existence is strong. Yet I do not think that we are compelled to infer that all posthypnotic suggestions exist actually nor yet that all potential memories have an actual existence. For the present I would rather regard the subconscious state as something to be accepted only when definite evidence of its existence is forthcoming. Nor would I ascribe these states in all cases to a secondary or subconscious "self," although I regard the existence of such a self distinct from the upper self as in some cases probable. Subconscious states when they do exist are probably like our dreams.

The emergence of the suggested state into the upper consciousness sometimes seems to have no appreciable effect upon its constitution. The new element presents itself to the patient much as other elements do, and may meet with opposition from those already existing as would any other. Thus one of Mr. Gurney's patients "was told to bring the spoons out of the dining room into the drawing room, which was properly the maid's duty. She was left to wake in the dining room, and presently followed the rest of the party into the drawing room, saying, 'I know what you want me to do, but I don't mean to do it; it is too absurd.'" She had no recollection of what she had been told, but when the irrational impulse presented itself she suspected its origin and refused to obey it.

At other times, by a species of illusion of memory, the suggested impulse is referred by the patient to some consideration from which it might very well have sprung. A friend of mine hypnotized a young girl, and told her that when he coughed three times she would say good-night to the assembled company and leave the room as if going to bed, but at the foot of the stairs she would turn back. She did it punctually. When we asked her next day why she changed her mind, she said that as she got to the foot of the stairs it occurred to her how rude it was of her to go to bed while the callers were still there, so she turned back.

When a posthypnotic hallucination presents itself to an approximately normal consciousness of this kind it is received with appropriate emotions, and the same is true of negative hallucinations. X—— was told that after waking he would be blind to me. I then took a pencil and, holding it by one end, wagged it to and fro. The patient stared at it with a puzzled and somewhat frightened air. "There ain't nothing to hold it," he said, "but it stands right up and wags. Guess it must be hung by a string to the ceiling." But a diligent search revealed no string. I then grasped the pencil by two fingers about the middle. He became still more troubled, stooped as near the pencil as he could and examined it closely. "Somehow I can't see the middle of it," he said. "There are just two ends and no middle." It is dangerous to give a

patient of this type an alarming suggestion, for the terror which it inspires may do more mischief than the operator can readily undo.

Sometimes while the upper consciousness is apparently unaffected it will be found that the performance of the suggestion is either forgotten or entirely unnoticed. Prof. Janet says of his patient Lucie: "She seemed at the moment quite normal, talked and kept record well enough of the acts she performed spontaneously, but in the midst of all these normal acts she also performed as if by distraction the acts commanded in sleep. Not only did she forget them when performed like most subjects, but she did not seem to be conscious of them the moment she did them. I tell her to raise her arms over her head after waking. Scarcely is she in her normal condition before she raises her arms above her head, but she does not inconvenience herself thereby. She goes, comes, talks, and all the while keeps her arms overhead. If asked what her arms are doing, she is astonished at such a question and says: 'My hands are doing nothing at all; they are like yours.' By this method I make her put her fingers to her nose and walk across the room. I command her to cry, and upon awaking she actually sobs, but in the midst of her tears talks of the most cheerful matters. The sobs over, there remains not a trace of her grief; indeed, she seems to have been unconscious of it."

These may be regarded as the extreme types, the posthypnotic suggestion in the one case coalescing with the upper consciousness, and in the other remaining absolutely dissociated from it. There remains a third type in which the suggestion emerges into the upper consciousness, but in so doing seems to disordinate it to a greater or less degree, thus reducing the patient to a condition analogous to that in which he was when the suggestion was given.

The disturbance is often very slight and it is then not easy to detect or define it. It may be limited to a transient look of abstraction, of vacancy, as if a cloud were passing over the mind. What I have described as failure to coalesce may be conceived as a form of interference in which the suggested state expels from consciousness all inconsistent states without much affecting the balance. At other times if one gives a suggestion the execution of which takes some time, the patient will be found sensitive to fresh suggestions while the first is being executed, or will be found to recollect at that time previous states of somnambulism which are forgotten in his normal condition and are again forgotten, together with the act just performed, a moment afterward. Sometimes the disturbance of the upper consciousness goes further and results in complete disordination or "unconsciousness." I have often seen this as the result of giving suggestions which were too

difficult for the patient's already partly disordinated consciousness to execute or were resisted by elements already present. A good case of the latter type is quoted by Mr. Gurney from Prof. Delbœuf. "He told the patient to straighten a crooked knitting needle at a future moment when he foresaw that to do so would necessitate drawing the needle out of the stocking and spoiling the work. When the moment arrived she solved the difficulty by going to sleep and *dreaming* that she straightened the needle." I told T—— that he could not see two chairs, and then caused him to walk into them. Asked what impeded his progress, he said "The wall." When I showed him that could not be true, and insisted upon his telling me what it was, he fell into a deep lethargy and collapsed in a heap on the floor. He nearly always falls asleep when told to execute any complicated suggestion. Patients who pass into a secondary state during the execution of a suggestion often manifest no more surprise at the most extraordinary hallucinations than one usually feels when confronted with the marvels of dreamland. T—— described in all detail how a cup of chocolate, which was held by a person I had forbidden him to see, was hanging in the air all alone, how the spoon was traveling around in it quite of its own accord, but he seemed to find it entirely natural. This is due to the fact that surprise is one of the ideal emotions originated in the clash of inconsistent states. Here the hallucination found no sensations or thoughts in the disordinated state with which to clash.

The whole question as to the relation between the posthypnotic suggestion and the normal consciousness is involved in much obscurity, which is the more to be regretted when one considers that upon it depends the solution of that other vexed question as to whether suggestions can be used to further a criminal end.

To the best of my knowledge, no indubitable cases are on record in which a person was impelled by posthypnotic suggestion to the commission of a crime which he would not have committed of his own motion, although there are a few cases reported in which criminal assault was probably committed during the hypnotic state. The evidence, therefore, is almost entirely experimental.

It is clear that the control of the operator over the patient during the hypnotic state is often almost unlimited, and undoubtedly might be used for the commission of crimes which could be completed during the state without danger of detection to the suggester. There are, however, not many crimes that could so be committed. Signatures could be got by such means, but even when got the suggester would often have difficulty in making use of a signature which was not witnessed or which was repudiated as a forgery by the man who was supposed to have written it.

The possibilities of posthypnotic suggestion would seem at first glance to open a wider field for criminal suggestion, but the evidence does not, I think, justify much apprehension on that score.

When the patient's consciousness is much disordinated by the suggestion, he is usually unable to co-ordinate himself to his environment, and is, of course, not fitted to do anything requiring alert mental powers, much less a crime. When the suggested idea expels inconsistent states the case is almost as bad. Prof. Liégeois dissolved a white powder in water and told Mme. C——, one of his patients, that it was arsenic. "I said to her: 'See M. D——, he is thirsty, he is always wanting something to drink; you will offer him this.' 'Yes, monsieur.' But D—— asked a question which I had not foreseen; he asked what was in the glass proffered him. With a candor which set aside all thought of simulation, Mme. C—— replied, 'It is arsenic.'" Clearly it would not do to intrust to Mme. C—— the execution of a suggested crime.

Again, when the emergence of the posthypnotic suggestion does not affect the upper consciousness at all but coalesces with it, it is apt, as I have already pointed out, to meet with resistance from the patient's habitual principles of conduct. Dr. De Jong reports that a little Jewish girl of ten, whom he found very suggestible, repeatedly obeyed his posthypnotic suggestion that she should steal a piece of money left lying upon the table, but one Saturday she disobeyed. When asked why, she said: "It is the Sabbath day; I can not touch money." Another of his patients performed all manner of make-believe crimes at his suggestion, but, when he suggested something the performance of which would have shocked her modesty, she refused, and she refused also to betray a trivial secret which he had got his cook to confide to her.

When one contrasts cases of this sort (and they are common) with the long series of "laboratory crimes" recorded in the annals of hypnotic literature—murder committed with sugared water, with a roll of newspaper, with an unloaded pistol, the theft of purely imaginary objects, or of articles obviously the property of the man who suggests that they be stolen, etc.—it is difficult to avoid the conclusion that for evidential purposes such experiments are almost worthless. And in the few cases where it seems probable that the patient has really committed what he believes to be a crime, it is often not shown that the crime would have been especially abhorrent to his normal self. This objection attaches, I think, to one of the most striking cases on record, recently reported by Prof. Liébeault. A certain Dr. X—— and himself gave a young fellow of seventeen or eighteen years of

age the following suggestion: "To-morrow, at 11.30, you will go to call upon M. F——. You will be received in his room and will see upon the chimney-piece two statuettes; you will carefully possess yourself of them after talking of sundry things, and will carry them off hidden under your clothes. But day after to-morrow you will repent of what you have done, and, seized with remorse, will return the statuettes to M. F—— at about the same time of day." Then, just before Prof. Liébeault awakened the patient, Dr. X—— said: "You will steal, you understand; you will steal." The suggestion was punctually executed. Two months later the boy was arrested for the theft of an overcoat which he took in a very stupid and obvious fashion, and upon his person was found a written list of petty thefts recently committed, among them being that of some visiting cards. Dr. Liébeault, believing that the indeterminate suggestion given by Dr. X—— was at the bottom of the whole matter, got a lawyer to undertake the defense, and secured the diminution of the penalty to two months' imprisonment. Four years later, when the boy came of age, Prof. Liébeault hypnotized him again, his parents not allowing it while he was a minor. In the hypnotic state he claimed that about the time he stole the overcoat "he had met Dr. X—— in the street, had gone with him to a *café*, had been hypnotized and told to steal watches, pocketbooks, gloves, etc." The theft of the overcoat was specifically suggested. This case proves that theft can be occasioned by suggestion, but it does not prove that it could be successfully suggested to an honest and upright patient. For aught that appears, the boy would have stolen if a companion had put the idea in his head in his waking state.

A still better illustration is given by M. Focachon, which I take from Prof. Liégeois: J. D—— is a seamstress, aged twenty-seven, nervous, not hysterical, not very intelligent, uneducated, of recognized honesty. While hypnotized, M. Focachon suggested to her that she should steal from the closet of one of her employers some cloth, should bring it to M. Focachon's house, and should borrow the use of the sewing machine to make it up. "J. D—— at first protested very vigorously, asked what I took her for, wept and begged me to wake her, that she might no longer hear such propositions, but quieting her little by little, minimizing the importance of the theft, telling her it would never be known, and playing upon her vanity, I finally got her to say she would think about it." The suggestion was obeyed, but before she made the goods up M. Focachon hypnotized her again, took it from her, and abolished her recollection of the whole matter.

If such cases put it beyond question that suggestion may be used for the performance of crime, they also, I think, make it evident that the danger is not one of great magnitude. If there

are in the community a few individuals who, although of good natural disposition, are so weak that they can be used as passive instruments for the performance of crimes, there are probably very few of them; those few are seldom known; if known, they will seldom fall into the hands of a person inclined to abuse their weakness, and, if they do, the part played by the hypnotizer will frequently be detected.

But if the dangers of criminal suggestion do not appear serious, there is a real danger connected with its possibility. The plea of "emotional insanity" often adopted by sympathetic juries is becoming somewhat timeworn, and in hypnotic suggestion adroit lawyers may find an even more dangerous substitute. Suppose, for example, that A—— is accused of a crime for which no adequate motive can be shown. But B—— had a motive for its commission; B—— is acquainted with the phenomena of suggestion, A——is known to be extremely suggestible, and B—— has had ample opportunity of influencing him. In such a case no amount of evidence that A—— committed the crime could set aside in my mind a "reasonable doubt" of A——'s guilt. The occasional escape of a criminal on this pretext I would not regard as a great matter, but the stigma which his acquittal would cast upon B——, a stigma not the less real because incapable of proof or disproof, is a serious thing.

A similar line of reasoning has been used once at least with what seem to me more happy results. On the 25th of January, 1888, a young married woman—Mme. G——, the wife of a French engineer living in Algiers, and said to be one of the most beautiful women in the country—was found lying dead not far from her home, with two bullets through her head. Near by lay a man named Chambige, a friend of her husband's, seriously wounded but living. Chambige claimed that Mme. G—— had been in love with him and he with her, and that they had agreed, in view of the hopelessness of their passion, to die together; he had shot her first and then himself. There was not a shred of evidence to show that Mme. G—— had ever had more than a friendly regard for Chambige, mingled perhaps with the pity a happy woman feels for a lonely and disappointed man. To all appearance she had always been a most loving and virtuous wife, with no thought for anything but her husband and children. It was proved that on the day of her death she had seemed as placid and cheerful as usual, showing not a sign of mental perturbation; that she was in the highest degree hypnotizable and suggestible, and had frequently unwittingly hypnotized herself by looking too long at a fixed point. It was also shown that Chambige had been madly in love with her, that he probably was acquainted with hypnotism, that he was a restless and unbalanced spirit

without religion and without morality. Prof. Liégeois, of the Faculty of Law at Nancy, has published a study of the case, in which he endeavors to show that Mme. G—— was in all probability innocent, that Chambige hypnotized her in the parlor of her own home on the morning of the day of her murder, and then lured her to ruin and death by a posthypnotic suggestion. No one, I think, who is at all acquainted with the possibilities of suggestion will deny that Prof. Liégeois's interpretation is within the realm of possibility, and for my own part I am inclined to regard it as more probable than the tale told by Chambige. If the theory of suggestion had done no more than clear this young wife's memory from the stain cast upon it by her murderer, it would be worthy of serious consideration.

To sum up, I believe, with Prof. Delbœuf, that the danger from criminal suggestions, although real, is not much greater than that arising from criminal dreams. It is known that crimes have been committed by somnambulists as the result of the dreams which possess and control them, but we do not regard the fact as a reasonable ground of apprehension. We can not lay too much stress upon the fact that the phenomena of hypnotic suggestion, strange as they appear to the uninitiated, find their nearest normal analogues in those of sleep and dreams, and are subject to much the same limitations.

WOMAN AND THE BALLOT.

By ALICE B. TWEEDY.

IF every man considered it a matter of conscience to give voice in his vote to the feminine element in his household, it would put another aspect upon the demand for woman suffrage. If, after a family conclave, the husband, father, or brother quietly pocketed his own conflicting opinion, sallied forth and supported the measures favored by the home majority, what right-minded woman could complain? It would be merely an extension of the main principle of republican government. Only those women without male relatives would be unrepresented, and for them special provision could be made.

This hypothetical condition, however, is so far from fact that it sounds facetious, and the picture of a household wherein a gentle-minded man revises his sentiments to adequately set forth the contrary views of his womankind seems altogether Utopian, yet such a situation is one in which it might be justly claimed that men were the actual political representatives of women.

Some men there are, though *rarissimæ aves*, fair enough to

acknowledge that woman ought to be represented in this fashion, or else allowed to deposit a ballot for herself. The proposition of woman suffrage alone does not trouble them, but they stumble over the corollaries of political life and officeholding, and, rightly judging that the trio are logically involved and claimed by suffragists, they demur at the result or reject all together.

Political avocations seem to them utterly alien to the womanly nature, or at least to what they know of it; and since their conception of this elusive quality is undoubtedly founded on the particular instances which have fallen within their experience, it would be useless to oppose it with a flurry of words. One of their number, however, in a paper on The Political Rights and Duties of Woman, is explicit, and furnishes us with several statements which may be debated. To the performance of political functions by women, he holds there is "a serious natural impediment" that "four fifths of the women all the world over, between the ages of twenty and sixty, are occupied with paramount domestic obligations incompatible with public service." "Under this disability of Nature, or closely related to it, all the objections to the exercise of political functions by women may be classed, so that no other objection need be considered."

It is no longer, then, a vaporous theory that confronts us, but an array of questionable facts. The condition of four fifths of the women "all the world over" is certainly beside the issue. We have no reliable statistics regarding them, and we are not at present concerned with their political disabilities. The ballot is demanded only for the women of civilized communities, where the right of suffrage is already possessed by men, and the question is immediately pertinent to those in the United States. Here statistics are available, and in New York State they run as follows:

Women between the ages of nineteen and sixty-five.

Total number		1,707,655
Married women	1,244,291	
Mothers *	1,238,070	
Mothers disqualified for public service		550,252
Eligible women		1,157,403

= 67 per cent of the whole.

Comparing men, we find certain classes among them ineligible to political office by reason of their professional or business duties, yet disfranchisement of their sex on that account has never been considered. Priests and ministers of the gospel, even if devoting some time to politics, could not give to public office "that entirety

* The general proportion of mothers among married women is ninety-five per cent. Of these, the maximum number disqualified would be four ninths.

of energy which an official oath exacts" without disregarding the spiritual welfare of their flocks; and if they are true pastors, it would not be amiss to compare them in the multiplicity of their cares to the mothers of young families. Physicians in active practice can not well be judges or sheriffs without neglecting the vocation for which they are especially fitted. Scientific men engaged in original research are not expected to abandon their laboratories, where they may be on the eve of bringing forth the fruit of lives wedded to patient observation, even if a mistaken populace should nominate them for mayors or Congressmen. Manufacturers and business men have even been known to decline senatorial honors, since these conflicted with the responsibilities of their callings.

If a count could be made of all these men who, for various reasons, will not accept political candidacy, it might be found to equal in number the mothers who are disqualified for office-holding.

It is to be observed that at any given time only a minority of mothers are even thus conditioned. That four fifths of womankind between the ages of twenty and sixty are ineligible for public office proves thus to be an exaggeration.

Planted upon this astounding proposition, our antisuffragist then proceeds to discuss the complications that may arise if women enter upon political life. While they attend committee meetings, the scarlet fever may invade the nursery. If they engage in jury duty, the husband, fretted with financial cares, will fail to find sympathy at home.

It may be presumed that women with young children will not generally accept candidacy for public office; but should they in some cases think best to do so, such contingencies are not unlike those that occur outside of political life. A wife is called to the bedside of a dying mother, one thousand miles away. She leaves her children; the measles breaks out among them, and the father, although an inexperienced man, nurses the flock back to health. Instances are not wanting in which men have wrestled victoriously also with other diseases, so that a great gloom need not settle down upon mankind at the prospect of a mother's occasional attendance upon a committee meeting.

The dearth of sympathy at home is no matter for jesting. No doubt thousands of women, in times of anxiety, have gone entirely unconsoled while their husbands were jurymen. If men have a taste of this experience, where is the injustice?

Not very relevantly our opponent breaks in here with the assertion that "the suffrage is a question of readjusting the occupations of men and women as established by all civilized and uncivilized people." As the occupations of men and women *vary* with

the state of civilization and the industrial development of a country, this generalization is valueless. The employments of men and women also depend upon the condition of the nation, whether militant or peaceful, and in regard to certain kinds of work no universal rule can be made. Women act as horse-car conductors in South America; Chinamen prefer the laundry in the United States; while in East Central Africa men insist upon sewing their own and their wives' garments, leaving the women to build the houses and hoe the corn. The modern readjustment of vocation in our midst arises, as it has been pointed out, from the increased leisure afforded women by the introduction of machinery. It is a wonderful evolution for woman, proceeding as noiselessly as the spinning of countless cocoons, liberating many who would have grubbed a hundred years ago to try their wings to-day if they will.

The next statement volleyed at us is very like an explosive used by Mrs. Lynn Linton in one of her harangues against women.* "The political disability is one irrevocably connected with that very office and *raison d'être* which called woman into existence."

Despite our advancement in science it seems next to impossible to extricate some minds from the mire of tradition. Brushing biology and common sense aside, these primitive souls continue to regard woman as the mythical rib of Adam. Those of us who have progressed beyond this dogma look upon it just as flatly contradictory to Nature as the biblical view of the earth as a plane. Woman's sexual life is shorter than that of man, her individual life longer. Therefore, if either was "called into existence" for the office of parenthood, it was obviously the man, not the woman. From a biological point of view the functions of life are two—nutrition and reproduction; and there is as much sense in saying that nutrition is the reason of man's existence as to state that motherhood—if that be "the office" meant—is the "*raison d'être*" for women.

As for us, we frankly confess we do not know anything about "reasons of being" or causes of existence. If Mrs. Lynn Linton, Mr. Talbot, *et al.*, have been taken into the creative confidence, no doubt they have interesting revelations to offer the world!

Our antisuffragist, not being quite content with delving into prehistoric purposes, next hazards a prophecy of the feminine officeholder. As wives and mothers are, according to his premises, ineligible, only "those who have made shipwreck of their domestic ventures," the forlorn and *déclassées*, will pose as nominees.

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* The Wild Women as Politicians. Mrs. E. Lynn Linton. Nineteenth Century, July, 1891.

He provides, however, "a contingent disability," that of getting married, which may overtake these. As our prophet waxes eloquent over matrimony he forgets what manner of woman he has pictured as a politician, and tells us "only intelligent and agreeable women will be popular, and only popular women would be candidates and elected." The forlorn and *déclassée* woman is metamorphosed into "the brilliant, educated, and accomplished lady stump speaker," and when she marries, what can be left for the suffragists?

Having thus disposed of the phantasmagoria of his creation, he asks two momentous questions:

1. What wrongs are there affecting society which the women's vote will set right?

2. What oppression does woman suffer at the hands of man which she must rise in her might to redress?

I am not aware that woman suffrage is proposed as a panacea for social evils, or that it will usher in a millennial condition. Man would be disfranchised if such requirement was made of his vote. Legislation does not beget character, and man is not made temperate and pure by law. Stringent laws, however, are needed to prevent various evils and to make certain offenses punishable. Women are quick to recognize vicious tendencies that men with a greed for money-getting often overlook. The work of Mrs. Fawcett in England, and of many earnest women in the United States, shows what good would accrue to society if women helped to frame the laws.

Our opponent does not pause to consider whether woman's vote would be beneficial or not to the community, but spends his full strength in fortifying the second query. "The woman's grievance against man, what is it?" he asks. "The moment you attempt to inflate its emptiness . . . you are dealing with hysteric fancies rather than hard facts. . . . Woman has no grievance against man. . . . Cruel Nature has committed an offense against woman."

English law is more nearly defined as "a hard fact" than as "a hysteric fancy," and English law contains a long "bill of grievances" which woman may publish against man.* True, in this land of boasted freedom most of these laws have been repealed, many others are a dead letter, and still others have been enacted that favor woman. These changes have been brought about by the growth of the sense of justice, but also directly through the efforts of women agitators who have pleaded and written against decrees of oppression. These writings and arguments are a matter of record, and they antedate all betterment of

* John Stuart Mill. Subjection of Woman, pp. 56–58.

the laws relating to women. Without them we do not know when "man's own sense of equity and right" would have impelled him to annul the obnoxious statutes. Even here in New York we come occasionally upon instances which betray the defects of a masculine code;* while in the civilized countries of Europe the laws generally discriminate in man's favor.

Outside of unjust enactments, the former subjection of woman is stamped on our customs, our literature, and our language. It is hardly possible for any one to investigate the origin of many of our conventionalities, titles, terms of obloquy, without coming unexpectedly upon proof of man's injustice to woman.

It is not intended to reproach the present generation of men for these or any other sins of their forefathers, as I hold all antagonism of the sexes as unnatural and vicious. Had women possessed the physical force, I think it very likely they would have acted as badly as their male ancestors. Yet it is instructive to note the tendencies and results of abuse of power, and an exclusive manhood suffrage is in this age and country a retention of power unwarranted by reason.

In primeval society, our antisuffragist allows that "the male and female were more nearly balanced in what each was called upon to endure." He adds that, although civilization has improved the lot of man, it has not "redeemed woman from the primitive sufferings by which she consecrated her motherhood." As to what sufferings primitive woman had I do not feel quite sure, but can agree that civilization has not yet accomplished a physical redemption for woman, although it is now alive to the fact that she has a physique to be developed. On the contrary, it has hitherto distorted her and artificially increased her weakness under the pretense of differentiating her from man. Her own stupidity and vanity are occasionally at fault, but man is not guiltless, and if another distinct grievance is wished for, it is here. Nature is not cruel; according to the words of the old hymn, "only man is vile." Let us say instead, man is a blunderer.

Our opponent reaches at length his principal tenet: women are a privileged class. Their privileges consist not in the minor courtesies of life, but in various immunities and exemptions which are "a generous attempt on the part of men to make for their mates and yoke-fellows an easier pathway through a rugged world. . . . Having in the right of his strength the opportunity to determine the customs of society, he has exempted his mate from

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*A woman appointed administratrix refused to pay an exorbitant bill. Her arrest for contempt of court resulted in the death of her babe. The surrogate said it was a case of great injustice, but the code made it mandatory upon him to issue the order (New York Times, June 11, 1890).

all those vocations that expose to premature death or great physical suffering." An inventory of these exemptions follows:

1. From the perils, wounds, and deaths incident to war.
2. From all kinds of labor dangerous to life or exposing to hardship and privation.
3. From the care of earning her livelihood and that of her offspring.

One is at first sight aghast at this record of masculine arrogance. Women might retort, and say Men have exempted themselves—

1. From the care of their progeny.
2. From the preparation of clothes, food, and household toil.
3. From nursing the sick.

All these "exemptions" are misnomers. Men have "exempted" women from nothing. They have excluded women in former times, and still exclude them in some degree, from the higher institutions of learning, the professions, and government. These exclusions, however, would form another "bill of grievances." The immunities mentioned are purely imaginary. Man *chooses* to fight, to sail the seas, to dig for gold and iron, to hew wood, and cut his own pathway in the world because he is a man and likes it, not to save any woman nor womankind from such tasks. He has the combative instinct that greets a struggle, the well-knit muscles that crave vigorous action, the adventurous spirit that courts the unknown, and the courage that defies danger. Does a boy wrestle with his playfellow to spare his sister; or run away to sea, or to the gold mines of South Africa, from an altruistic feeling for womankind?

Neither do men go to war or enter upon any dangerous calling with the purpose of exempting women. When John takes the peach and hands Jane the apple, we do not say, "Jane is exempted from eating the peach." Were all womankind swept from the earth to-morrow, men would not bury their weapons nor let the ships drift. Love of the other sex is a spur to the endeavor of either, but the choice of occupations calling for physical force is instinctive with the sex possessing it in greatest degree. All intellectual pursuits are feminizing in tendency, and it is only with men engaged in these, only with the smaller number among them who have allowed their masculine instincts to become atrophied, that the fallacy of "exemption" would take root. The wrestler, the sailor, the Alpine hunter, the blacksmith, would laugh such a creed to scorn. Men have not exempted women from deeds of force, from war, from labor, nor from self-support. They have generally chosen these offices for themselves, and left women to do the things that were left undone.

Woman is not only weighted by these gratuitous immunities,

but, according to this document, her natural delicacy is owing to them, and she is warned that she may part with womanhood if she persists in her unnatural endeavor to change her occupations. The bee is cited as an example that "sex itself may be determined by continuous special regimen or diet."

Now, so far as any naturalist has observed, sex is not *altered** by any regimen or diet; and as the subject of our inquiry is not a neutral bit of protoplasm, but a developed individual, woman, we do not need to study the origin of her differentiation so much as its possible modification.

The bees, with instinctive wisdom, feed the male and female larvæ differently, just as we, regardful of distinct uses, furnish varying food to the cow and ox. Yet, as the utmost change in nutrition does not result in transference of function in the mature organism, we need not fear that a different environment will ever rob woman of her essential womanhood. This specter, used to frighten girls from a higher education, is still the favorite totem of the tribe of viriolaters.

Our antisuffragist falls into another grave error when he seeks for "the instinctive tendencies of the dominant sex" in an era and in localities where woman has partial sway. It is not generally in the United States—certainly not in a city of New England—that we should look for the gross masculine ignorance that makes woman a beast of burden. It is in primitive communities that the anthropologist investigates the habits of man as the best exponents of his natural instincts. If we find in all such states of society the male is not inclined to relieve the female from hardship and toil, we can hardly argue that the divisions of labor found among civilized people arise from man's wish to exempt his mate from the arduous tasks of life. The Russian mother toiling in the fields, the Viennese woman laying bricks, the peasant girl harnessed to a cart, are better instances of man's "instinctive tendencies" than any to be found in American cities, where men have learned in some degree to subordinate instinct to reason.

Yet if one, being a woman, was forced to choose between toil in the fields, laying bricks in the sun, or a day at the washtub, it is not altogether certain that the last would be regarded as a privilege. It is possible that some women might prefer the first employments and desire exemption from the scrubbing-board. Moreover, if a child is needed to complicate the case, its chances of life may be vastly better with the flies in the open air than with the germ-laden atmosphere of a tenement.

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* The genesis of sex in certain orders seems to depend upon differing temperature and nutrition.

Thousands of women work in the mines of Belgium, England, and Cornwall.* In the first-named country they formerly worked from twelve to sixteen hours a day, with no Sunday rest.† The linen-thread spinners of New Jersey, according to the report of the Labor Commissioner, are "in one branch of the industry compelled to stand on a stone floor in water the year round, most of the time barefoot, with a spray of water from a revolving cylinder flying constantly against the breast; and the coldest night in winter, as well as the warmest in summer, these poor creatures must go to their homes with water dripping from their underclothing along their path, because there could not be space or a few moments allowed them wherein to change their clothing."‡ Yet women are "exempted" from labor attended by hardship!

Despite these washerwomen, miners, and linen-thread spinners, we are told "it is woman's privilege generally to be exempted from the care of earning her livelihood and that of her offspring."

It would seem to be time that this libel upon woman should be scorned by fair-minded men. From all antiquity the majority of women have been faithful workers, rendering a full equivalent in labor for their scanty share of the world's goods. The origin of every industry bears testimony to this. In our own era, while women were still homekeepers, did they not earn their livelihood? What was the weaving, the sewing, the cooking, the doctoring, the nursing, the child-care, "the work that was never done," if it was not *earning* a subsistence? Even in these days, when woman goes forth and receives the reward of her labor as publicly as man, she is no more worthy of her hire.* Her ancestress—sweet and saintly soul!—did not dream of recompense.‖ But was it not her due; and shall we refuse to credit it because man was then a self-sufficient ignoramus who deemed himself the only one fit to acquire property?

One by one the old industries have been transplanted from the home, and still man constructs new schemes of enterprise from the little tasks that once rounded out woman's day of toil. In the

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* Census of England and Wales, 1891, vol. cvi, table 6. Miners, female—*coal*, 3,267; *copper*, *lead*, *tin*, and *ironstone*, 1,425.

† *Vide* Report of Reichstag, 1889, forbidding women to work in the mines of Belgium on Sunday and at night.

‡ Report of Bureau of Labor, State of New Jersey, 1888.

* "The never ceasing industry of the women was the principal factor in the development of a manufacture that was probably contributing more directly to the personal prosperity and comfort of the people than any other then in existence in 1790" (Industrial Evolution in the United States, p. 20). Carroll D. Wright.

‖ Women colonists rarely worked for wages; . . . they carded the wool, spun the yarn, and wove the cloth for the male members of the family. In many instances they worked on the land, and did their share in every way to enable the family not only to secure a livelihood but to build itself upon stable lines (Industrial Evolution in the United States, p. 112).

census of 1890, three hundred and sixty-nine groups of industrial work are enumerated, and in all but nine of these women are employed, the actual ratio of women workers to men being 1 to 4·4. The United States Commissioner of Labor writes: "A careful examination of the actual earnings of women discloses the fact that in many industries their average earnings equal or exceed the earnings of the men."

It may be difficult for those not conversant with manufacturing towns to realize that as far back as 1850 there were over two hundred and twenty-five thousand women engaged in factory work, or 27·30 per cent of the whole number of employees. To-day, however, when women have swarmed into nearly all hives of labor, statistics are scarcely needed to prove that, whether "exempted" or not, they earn their livelihood in visible fashion. Dr. Mary Putnam Jacobi asks the observer to "station himself on Broadway at six o'clock in the evening and watch the crowds pouring out of the retail stores, the binderies, printing establishments, and newspaper offices, or to visit the ring of ferries encircling the city, and analyze into their component sexes the vast throngs returning from work; or, at the station of some manufacturing town, see the operatives disembarking for the day, and after such inspection he will find it hard to believe that any women remain at home to sew, dust, sweep, or mind the babies. . . . To his imagination the women of leisure would disappear as completely as in the United States the men of leisure are wiped out of the national census."

This phase of the industrial evolution is unrecognized by our antisuffragist, and he depicts for us how a census-taker would find the sexes relatively employed—the man going to work and the women engaged at home in household supervision and social duties. He admits that now and then women teach, act as clerks, or do literary work, but these are exceptions.* "In the healthy normal society the true order seems to be that 'men must work and women must weep,' unless a cheerful temperament converts the weeping into a song." This, which might answer for a poetical view of the lives of the fisher-folk of whom it was written, was not typical of the general social condition even in Charles Kingsley's time. To-day it is not true of a respectable fraction. The number of women who live in absolute leisure is an insignificant item and is constantly diminishing.

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* The percentage of women workers for the United States in 1880 was forty-nine. In 1890 the gain is stated to be ten per cent. The number of women employed in mechanical and manufacturing industries for 1890 was 505,712. They received as wages $139,329,719. There are 549,804 women in New York city over fifteen years of age. Those regularly employed number over 250,000.

It is not the casualties of life nor of business that drive women as a class into industrial occupations, but the constant inventions that liberate their time, once useful in the house. Woman's work has always been one of the main stays of the home, although men have cherished the fiction that they "supported" it. Now that man has laid violent hands on woman's former employments—cutting children's garments by machinery, baking, pickling, and preserving for the nation—it is inconceivable that woman, industrious woman, should fold her hands and sit in a corner. She has gone forth and sought for work; she has become "an economic factor," and this status is the *precedent*, not the *consequent*, of the ballot.

We are, however, informed that "women want the ballot in order that they may open to themselves a free career in all the professions and occupations in which men are engaged. . . . They wish to make *wounds* which the present social structure now receives its chronic status."

This diagnosis is faulty, the caution too late. The wounds were rifts in the larval envelope that woman has cast from her. She asks recognition now in the new order to which she is admitted.

It is to be deprecated that individualism in seeking its due should overlook what it owes to others. Women, in the past at least, have sought much more actively for duties than for rights, so that it is superserviceable for a man to suggest this course to them. Even yet some women need to be informed that they have any rights, such rights as the Constitution of the United States avers belong to every man—life, liberty, and the pursuit of happiness.

Our antisuffragist again brings forth the bugaboo which is dear to the conservative heart: the threat of unsexing woman.

"The inevitable ultimate result of subjecting the two human sexes to the same labors, the same employments, the same cares, will be just the same as when domestic animals have been subjected for long periods to the same conditions. Sexual differences, physical and mental, will tend to disappear, and the two branches of the race will tend to approximate a common type."

We can safely let the matter of sex rest entirely with Nature. It is a fundamental fact of our being, not to be disturbed by any little transformation scenes that we can bring about. We may go for analogies to the domestic animals, birds, or fishes, and in none of them will we find *sexual differences* disappearing or tending to disappear. What are called secondary sexual characteristics are very fickle in their nature, and do for various reasons often desert the sex with which they are identified. These are characters

merely associated with one sex but having no essential connection with the sex itself, such as the brilliant plumage of the peacock, or, as Mr. Darwin suggested, the baldness of Englishmen. These in a majority of instances depend upon the preferences of the opposite sex, the last example being a probable exception. So men have only themselves to blame if an undesirable type of woman persists.

In addition to these, artificial differences, mere resultants of specific treatment, may also disappear. The foot of a Chinese woman is quite unlike that of a man, and possibly an aristocratic Celestial dame would be fearful of approaching the masculine type if she allowed her daughter's feet a natural development. Barbarous nations are not usually content with Nature; they delight in differentiating their women from men by blackening their teeth or boring holes in their lips, ears, and noses. We follow their fashions in a mild way and have created several artificial types of women, but it is hardly scientific to call the exaggerations which distinguish them "sexual differences."

Among animals we can, by breeding and training* through several generations, increase desirable qualities, such as the pace of horses or flight of pigeons, but it is not claimed by any breeder or zoölogist that the sexes are any nearer each other than they were in protozoan times. It is also an assumption to declare that the "graces of womanhood—affection, tenderness, and sympathy"—have sprung from the relation of the sexes. According to all authorities, the general relation of the sexes in all but recent times has been characterized by anything but "affection, tenderness, and sympathy." So far as we have proof of the origin of these qualities, they have arisen from the offices of motherhood; and just in the degree that we elevate, ennoble, and endow the mother with moral, mental, and political responsibility, do we put it in her power to exercise the wisest affection toward her offspring, the fullest sympathy with her mate.

Our antisuffragist "fears to drag woman from her high estate wherein man is her servant." This has for me the melodramatic ring of "a hysteric fancy." With all the opportunities for progress which recent years have given her, it does not appear to me that woman is yet on so high a plane as man. She is, however, climbing step by step, and all unprejudiced men and women will welcome the day when she may stand beside him as his coworker in life. That the ballot, officeholding, or any other right which she can exercise or pursuit which she will undertake can render her less a woman, is a hypothesis without a grain of evidence. No

* In every case of change, breeding is certified to be more potent than mere conditioning; *vide* Alfred Russel Wallace, in the Popular Science Monthly, vol. xxxviii, p. 94.

biologist can hold it with any consistency. Over and over again such a result was predicted of education. As she was not educated out of womanhood, so she can not be metamorphosed by politics, and will remain, when acknowledged as an individual, still the counterpart of man.

THE SUBTERRANEAN RIVER MIDROÏ.

By Dr. PAUL RAYMOND.

THE investigations in palethnology which I have been pursuing for several years in the departments of Gard, Ardèche, and Vaucluse, France, have led me to explore the subterranean cavities, avens, caverns, and rivers which furrow the region of the Causses. In this way I discovered, in 1894, the subterranean river of Midroï, and found it so curious that I am impelled to describe it for those who are interested in explorations of the depths of the earth. The river Midroï is situated on the left bank of the cañon of the Ardèche, at the beginning of the defile of la Madeleine. Its mouth, marked by the rich vegetation that clothes the rocks around, is at a level of about twenty-feet above the average height of the river. Starting to explore this river on August 28, 1895, and carrying our instruments, our photographic apparatus, and our boat, the Microbe, with considerable difficulty across the slippery clay bottom, we passed into a gallery about thirteen feet long and ten feet high, contracting in some places to a few inches, which offered nothing of special interest. About one hundred and fifty yards farther on we came to a lake, where my progress had been stopped in a visit made to this place the year before. Launching the Microbe, we proceeded on our way to the unknown. We advanced between walls smooth and polished by the water upon this new Styx, which had a uniform depth of about ten feet (Fig. 1). After a few turns the lake became narrower; an arcade, and then a second, rose before us—the Gate of Mycenæ (*Porte de Mycènes*), as we called them, standing at the entrance to the second gallery. This was the end of the lake, and for the present of our sail. Making the boat fast at the first arcade, we lifted ourselves upon the second, straddling the terminal part of the lake where the slightest slip would have thrown us into it, and entered the second gallery among slender stalactite columns, finely notched on the edges (*stalagmite des crénelures*). A change of direction, and we were in the hall of the Dome (*Escaliers des Stalagmites* and *Salle de Bifurcation*), the vault of which is more than thirty feet high. The gallery forks here, one part going due north, the other part opening opposite,

toward the south (Fig. 1). First a wall of stalagmite barred our road; then we had to scramble over a series of pot-holes, some of which were full of water; and we then entered the passage of the bowlders, enormous blocks fallen from the roof or the walls and

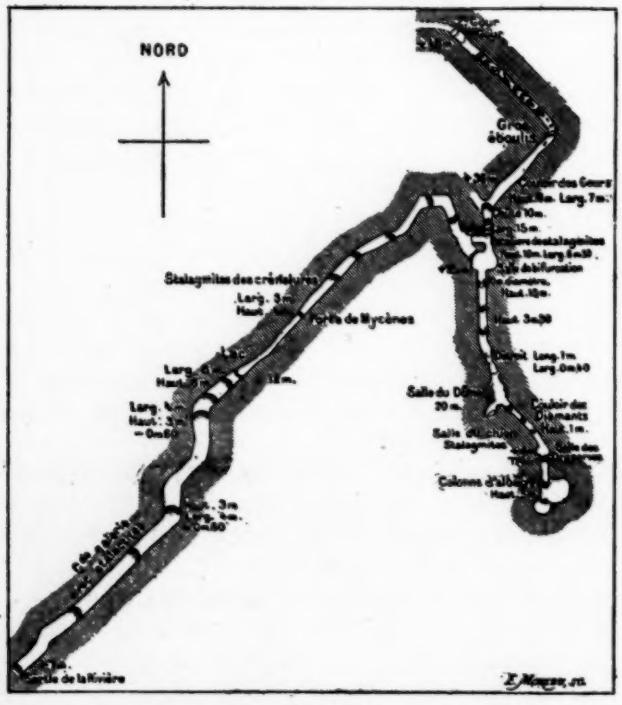

FIG. 1.—PLAN OF THE SUBTERRANEAN RIVER MIDROÏ. (Drawn by the author.)

carried along by the waters, worn and polished, which were chaotically piled upon one another along the rapid descent (*Couloir des Gours* and *Gros Éboulis*). Around these blocks we walked upon a shingle of small worn fragments of stalactite, flattened by the violence of the waters. There was still a pot-hole more than six feet deep separated from another lake by a mass of stalagmites on which we would have to balance ourselves in order to hoist the boat. It was so narrow that we could not do this, and we had to invent a novel system of ballistics to get the Microbe, which was upward of two hundred yards away, through the difficult passage. And it was very vexing to be stopped, for in a moment the river turned to the west, toward the Rochemale Spring, which we regarded as an issue of the Midroï. With all requisite precautions we took up specimens of the water from this pot-hole, which we planted in culture tubes for the microbiological researches we were prosecuting on the water of caverns. The thermometer, which marked 29° C. outside, had fallen to 14° C.

The barometer indicated that we were one hundred and forty-three feet above the mouth of the river—a considerable fall in a course of eleven hundred and forty feet. After a few moments of rest, we turned back, and, crossing the hall of the Dome, we engaged ourselves with the southern gallery, which presented quite a fairy spectacle. In this succession of little halls connected by narrow passages, where we had to pass creeping, the stalactites were crowded in front of us, innumerable, resplendent, lengthening out into slender spindles, graceful little columns, and marvelous pendants, intact and immaculate. A few steps farther on, in the Diamond passage (*Couloir des Diamants*), the spectacle became grand. The roof, the walls, and even the ground were tapestried with crystals cut in facets, which shone under our lamps in dazzling brightness. While absorbed in the scene from the Thousand and One Nights, I heard my boatman Suau cry out, "Monsieur, there is a dog!" and then (*Salle du Chien*), in the half-light of the back of the hall, I saw it in my turn. It was sitting down and looked at us, but did not rise as we neared it;

FIG. 2.—THE SUBTERRANEAN RIVER MIDROÏ (ARDÈCHE, FRANCE).
(From a photograph.)

it was a block of stalagmite, which quite deceived us for a few seconds. Having recovered from our surprise, we examined the hall, passing from enchantment to enchantment. From the roof hung broad curtains of stalactite nearly ten feet long, and separated from one another by only a few inches, just enough to permit us to put our lamp between them. They

were so thin as to be translucent, and we caught the minutest details of their structure, the result of the long work of centuries (*Salle de Draperies*). Accordingly as the calcareous waters were or were not charged with salts of iron, bands alternately brown and white were deposited the whole length of the veil, simulating, in their regularity, the stripes of the richest tissues of the most complete factories. This hall, of all the caves I have visited, left the strongest impression of the marvels to be met with in the bosom of the earth. Leaving this Hall of Draperies with regret, we continued our march, but were soon stopped, for the river went no farther on this side. We had traversed nearly five hundred and fifty yards in this resplendent cavern, and were now fifty yards above the mouth of the river. Before returning we took a second specimen of water for our studies. It came from a drip which would certainly in less than a year have caused the junction of a stalactite and a stalagmite, and never had we better observed the phenomenon of the union of calcareous concretions. A third specimen was taken from the dripping roof. As we have mentioned these microbic studies, we will also speak of the results we obtained.

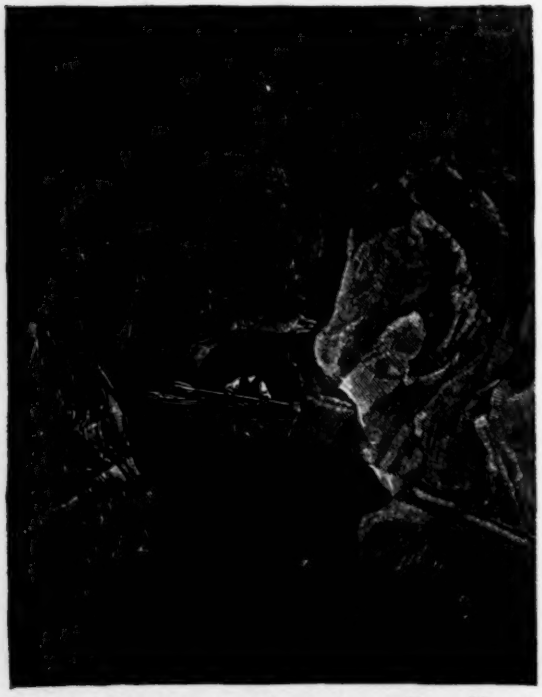

FIG. 3.—A PASSAGE IN THE SUBTERRANEAN RIVER MIDROI. (From a photograph.)

As a general thing, the culture tubes in which the water from the dripping roof, stalactites in course of formation, and pot-holes in which the water had not been stirred for a long time was put, remained sterile—that is, did not contain microbes. But when we examined a drop of water from the vents, or those fine springs that escape from the fissures, or from the pot-holes or lakes of these subterranean rivers, colonies of microbes were developed; the calcareous filter is no longer sufficient, and while it stops the coarse impurities of the waters that fall on the plateau, it lets the

infinitely small ones like the microbes pass. Although the thickness of the calcareous mass here exceeds eight hundred feet, the filter is not homogeneous, but is fissured; and through these faults, these cracks, in which the circulation is yet slow enough for the water, coming in muddy at the level of the plateau, to issue at the spring with admirable purity, the microbes continue to percolate. It is true that the microbes I have found are not pathogenic, but the importance of the studies can nevertheless be comprehended. If common microbes, brought in by the waters that fall on the plateau, can be found eight hundred feet below it, there is nothing to prevent noxious microbes—those, for example, of typhoid fever, diphtheria, or cholera—which may live in the water from being found there. There is in this a very interesting problem of hygiene and public prophylaxis. We should, then, be suspicious of these beautiful crystalline springs when there are epidemics on the plateau from which they come. They may contain micro-organisms—some indifferent, others dangerous. The microbes which I found belong to the genus micrococcus. Two of them (*Micrococcus aurentiacus* and *M. citreus*) developed in fine colonies of orange and citron-yellow colors; a third (*M. aquatilis*) gave no coloring matter. I obtained microbic colonies after the twentieth hour.

What, in short, is this underground river Midroï (Fig. 2)? A large fissure through which flow the waters drawn from the plateau by the avens, orifices, and cavities of every kind which make an enormous sponge of the mass of the Causses. In past centuries, when the mass of water that fell on the Causses was considerable, Midroï acted regularly and gradually enlarged the fissure; but now it acts only intermittently. Its vent then affords it sufficient outlet. Let me speak of this vent, the fine spring of Rochemale, which issues from the rock a little more than one hundred yards west of the orifice of Midroï. By this narrow fault, the communication of which with Midroï is highly probable, although it is not demonstrated, two hundred and twenty thousand litres of water escape every hour. In case the supply is doubled after great rains, the water, which can not escape by Rochemale in so large a quantity and in the same lapse of time, rises and fills all the meshes of the sponge. If the supply is increased again, the water flows into the river Midroï, which then comes into operation and the level of which may rise several yards, as is shown by the traces of wash-marks left by recent inundations on the walls of the river and which are shown in our photograph. There exists, in effect, in the very heart of the Causses, a considerable and eminently variable reservoir of water; it is a real lake, and through the thousand fissures, through all the meshes of this interior region, flow the waters of the plateau,

sometimes by the vent of Rochemale, and sometimes, and only when rains are abundant and when the vent is not sufficient for its task, by the river Midroï, constituting affluents to the Ardèche of a special order, many examples of which are known in rivers of the type of the Ardèche and the Tarn.—*Translated for the Popular Science Monthly from La Nature.*

OUR SOUTHERN MOCKER.

By I. W. BLAKE.

THE American mocking bird (*Mimus polyglottos*), although native to a country which claims to be democratic in principle, is by nature pure and simple a born aristocrat. It is true that at first sight he may be a disappointment to any one anticipating a bird of brilliant color; but the more one studies the mocker the more strengthened becomes the opinion that few birds, if any, can aspire to his dainty, high-bred personality, or to his slender grace and elegance of movement. Indeed, to this unconscious, inborn "Delsartean" ease, poise, and lightness, as well as to his marvelous power of imitation, the mocker owes his attractiveness; for this sleek fellow in his sober coat of gray—tipped with black, and lightened only by a glimpse of white when he spreads his wings—can lay no claim to beauty of feather as an additional charm to win him admiration. The plumage allotted him by Nature serves merely as a background, so to speak, which shall not distract the eye while his listeners pause in wonder as he fills the clear air with his marvelous melody.

The bird lover at the North, who sees the mocker caged, gloomy and despondent or restlessly beating himself against the merciless bars of his prison, knows nothing of the real power of the bird until he hears him singing at full liberty in the brilliant sunshine of his native heath, for the variations in the song of the mocker depend largely upon his surroundings. Thus, in a city he quickly acquires loud, sharp, and unpleasant notes; while in the country, where incessant barn-yard music reigns supreme, he soon adapts himself to his position. Take him, however, free, happy, saucy fellow that he is in the South, in localities where he hears few sounds but the voices of clear-throated birds, and his song is naturally mellow and sweet, standing unsurpassed in its wonderful modulations and gradations, compass, and brilliancy of execution. The mocker seems instinctively to select the prettiest quirks and quavers he can gather from his neighbors. Many of the sweetest notes in his *répertoire* he acquires from the red or cardinal bird, which has certain liquid, flutelike whistles, all of which our little

imitator quickly appropriates, without even the grace of an acknowledgment.

The mocking bird, like all aristocrats, has no humility in his "make-up," and at times this disposition makes him most exasperatingly overbearing—as, for instance, when choice fruit is slowly ripening and the contest begins, to ascertain whether the landowner or Monsieur Mockey shall collect the harvest! Firmly believing himself to be lord of all, the premises resound with the queer, fierce scoldings which he bestows upon all usurpers, and our little gray-coated songster shows a pugnaciousness that is surprising. The sound of a mocker's scolding resembles the sudden splitting of long strips of heavy silk, and, as he has a habit of leaving his voice all along the path behind him as he flies angrily away, fretting and disputing at every step, the sound is so fierce, so long drawn out, and so far extending, that one involuntarily sniffs the air for the sulphurous odor which should, by right, accompany so savage a train of ugliness.

The housekeeping and family cares of a pair of mockers are wearing to themselves and to the entire neighborhood, and attractive as the bird may be in his adult years, as *enfant terrible*, in all the agonies of the preparatory and freshman year, he is a nuisance of the most tiresome type. As soon as the little ones are coaxed from the nest for their first outing the trouble begins, and the exertion necessary to find sufficient food to fill those never-satisfied, gasping, shrieking throats reduces both parent birds to gaunt and peevish little gray ghosts before the month is out. Indeed, the very sight of this practical, unpoetical side of real life would make many a student of the much-discussed question, "Is marriage a failure?" pause and cry out mentally, "Blessed be single bliss!"

After some four or five weeks of tribulation, these baby mockers—such as escape the sharp beak of the murderous shrike or butcher bird—enter the sophomore class, instinctively assume tall hats, and begin to feed themselves. In spite of the annoyance of their tiresome shrill piping, almost incessant from dawn until sunset, silent only from necessity when their throats are being stuffed with the hard-earned food, they are a funny sight as they sit perched in a row upon a fence-rail, with their tiny feathers fluffed out until the little fellows resemble soft, gray puffballs. There, occasionally flying to some neighboring low-growing shrub for a change, with wings fluttering unceasingly and with heads thrown back to give greater voice room, they will sit for hours, their shrieks arising to squeals of indescribable ecstasy when the old birds approach with the coveted worm. Should a cat chance to stray into their neighborhood, it is very comical to see them all shake, or rather shudder, their tiny wings violently, as they alter

their food call to a harsh *scrawing* sound, thus calling the parent birds back to the rescue.

Putting aside the family question, the mocking bird is, of course, the prettiest and most attractive when the instinct of mating is predominant. As each pair build usually three or four nests, and rear from four to five young at each nesting, one may have many opportunities to witness their courtship methods. The prettiest sight of all is the courtship dance, which should be seen to be appreciated, owing to the deep solemnity and apparent earnestness of the birds. Imagine a large chessboard laid out in chalk lines; make it, say, a yard square; then place the birds thereon, diagonally opposite to each other, one at each extreme corner. The plan of the dance seems to be that they shall hop, or rather bound, slowly from one end to the other, always in a straight line, and not for any one moment to stand directly facing each other, except at the instant of passing.

With bodies stiff and straight as an arrow, head erect and feathers flattened, wings drooping loosely forward, but tails elevated at as acute an angle to the body as possible, the dance solemnly begins. The eyes are steadily fixed, and as methodically as any soldiers upon drill they sturdily go through the movement of bounding, rising quite high and descending in very nearly the same place each time, from one end of the playground to the other, back and forth, always keeping the line about a foot apart. As each one nears his or her corner, each slowly and dignifiedly turns a complete circle, then again faces the other, always diagonally, and slowly bounds back, to repeat the movement at the other end. Sometimes both will turn away to look off at some distant object, just as a cat will apparently forget the mouse she is tormenting. That, however, seems to be only a part of the ceremony, for soon both turn back and the dance is resumed.

One day I chanced to witness one of these pretty sights as it took place beneath the wide-spreading branches of a large orange tree, but the scene was interrupted quite unexpectedly. Just at the most graceful part of an intricate double pirouette, a very puffy and motherly old hen who, with an unlimited number of offspring, had been serenely picking up a dinner close by, evidently felt a sudden impatience at the sight of all this folly, for to my surprise and amusement she made a quick rush and dashed between these happy mockers, startling them almost out of their senses. Instantly the atmosphere was permeated with two separate and distinct streams of silk-splitting fire, each fully a rod long, as the two angry birds departed for the protection of a neighboring lemon tree.

The mocking bird instinctively selects a high perch from which to deliver his song, and the bare boughs of a dead pine tree, or

the topmost, ever-swaying branch of an orange or lemon tree, he finds well suited to his taste. He is a pretty sight when in some similar position, steadfastly facing the strong ocean wind which tosses his soft gray feathers in breezy fashion, he carols his sweetest to some half-indifferent *inamorata* not far distant. His little, slender body quivers with excitement in his efforts to drown the song of some stout-lunged rival, who sits gayly perched upon the gilded vane that surmounts the house top; now stopping short in the very middle of a note to hear if that other fellow has discovered his new combinations, and then, as he finds to his dismay that the rascal has them already down to a very fine point (with the addition of several new and surprising twists of his own), starting off again at a tearing pace with a bewildering variety of kinks, quirks, and quavers!

Soon darkness comes upon the scene—for twilight is short in the sunny South—and our musical mocker has sought his snug feather bed in the tree tops; but, by midnight, should the moon chance to be in her full glory of semitropical splendor, the hated memory of that unconquered rival stirs his little brain, and he awakens to pour out his pent-up jealousy in notes that make the welkin ring. The longer he sings the more ecstatic he grows, and after a few sleepy attempts to keep up with the torrent of music, the rival ignominiously subsides, and our little hero has the field to himself, undisputed, till the dawn of another day.

SKETCH OF JAMES BLYTHE ROGERS.

SCIENCE has need of all manner of men among its votaries. He whose career will be traced in this memoir devoted to its service a warm sympathy, an inspiring utterance, a high degree of constructive faculty, and a conscientiousness which caused him ever to give his best efforts to the duty before him.

JAMES BLYTHE ROGERS was born in Philadelphia, February 11, 1802, being the first child of Hannah (Blythe) and Patrick Kerr Rogers. His grandfather, Robert Rogers, was one of the gentry of County Tyrone, Ireland. At the age of twenty-one he married Sarah Kerr, daughter of a gentleman living near, whose family, like his own, were adherents of the Presbyterian Church. Mr. Rogers was owner of the Edergole or Knockbrack estate, lying between Omagh and Fintano, forty miles from Londonderry, and held on lease a piece of land adjoining it. Dr. W. S. W. Ruschenberger, whose excellent memoir on The Brothers Rogers * is the chief available source of information concerning this family,

* Proceedings of the American Philosophical Society, vol. xxiii, pp. 104–146.

mentions as additional evidence of his social standing that he inherited the large central pew in the neighboring Presbyterian church, which he rebuilt and furnished anew when the church was reconstructed. Robert Rogers was twice married; his first wife bore him twelve children, and the second five. Patrick Kerr Rogers was his eldest child. "The rudiments of Patrick's education," says Dr. Ruschenberger, "were received in a schoolhouse built upon the estate. It is described as having clay walls, a thatched roof, clay seats covered with bits of carpet, and being warmed by a turf fire. The teacher was a lame rustic boy, whom Patrick's aunt, Margaret Rogers, a lady of notable intelligence, had trained for the office. It is conjectured that he acquired his classical learning from a private tutor at the house of a kinsman." The father of Sarah Kerr evidently did not believe in the law of primogeniture, for he had exacted, as a condition of his daughter's marriage to Robert Rogers, a settlement of all the latter's lands upon the children of this union, share and share alike. Accordingly, Patrick, although the eldest child, could expect only one twelfth of his father's landed estate, and must prepare himself for some other occupation than that of a landlord. "Entertaining opinions not rigidly orthodox, he was unwilling to enter the clerical profession, though he had the example of two uncles who were clergymen." All things considered, a commercial career seemed best, and he therefore entered a counting house in Dublin. When the Irish rebellion broke out, in the spring of 1798, he contributed to Dublin newspapers certain articles inimical to the Government, on account of which he was obliged to leave the country. At that period ships plied directly between Ireland and Philadelphia, and on one of these he embarked, landing at his destination in August, after a passage of eighty-four days.

In the following May Mr. Rogers obtained an appointment as a tutor in the University of Pennsylvania, and soon afterward began to study medicine under the famous Dr. Benjamin S. Barton. Mr. Rogers was married January 2, 1801, his wife being the youngest of the three orphan daughters of a Scotch father and an English mother. Their father, James Blythe, had been a stationer and newspaper publisher in Londonderry, whither he had gone from Glasgow. After the death of both parents the three sisters had come to America, where they were received by a cousin, Mrs. Thomas Moore. At the time of his marriage Mr. Rogers was described as "a tall, erect man, of grave deportment, having dark hair well sprinkled with gray, and soft, sleepy eyes. He played the violin and sang well, but never in company or in the presence of strangers, because such performance or display seemed to him inconsistent with the dignity of a gentleman."

After receiving his medical degree from the University of Pennsylvania, in June, 1802, Dr. Rogers began the practice of his profession in Philadelphia. He also took private pupils and lectured to classes in botany, chemistry, and other sciences. He was called to Ireland in 1803 to settle the estate of his father, who died in that year. This business disposed of, he returned to Philadelphia, bringing with him two brothers and a sister.

The next five years of effort did not bring him a satisfactory income and he removed to Baltimore, where he was more prosperous until he became involved in a controversy on methods of vaccination, which injured his practice. When Dr. Robert Hare resigned the professorship of Natural Philosophy and Mathematics in the ancient College of William and Mary, at Williamsburg, Va., Dr. Rogers was elected to succeed him. In this congenial position he remained, a competent and forceful instructor, until he died of malarial fever in 1828. His wife had succumbed to the same disease eight years before.

James B. Rogers received his elementary education in Baltimore during the residence of his parents in that city, and, after attending the College of William and Mary, took up the study of medicine in the office of Dr. Thomas E. Bond. In 1822 he received the degree of Doctor of Medicine from the University of Maryland. It is said that while a student he assisted his brothers William and Henry in teaching their school at Baltimore. After graduating he taught for a time a class of girls in conjunction with a Dr. McClellan, of Baltimore. This enterprise, proving unsatisfactory, was given up. Being now in need of employment, he thought of seeking the post of surgeon to a colony of free negroes which it was proposed to establish at Cape Mesurado. He consulted his father on this matter, and must have written a rather querulous letter, for he got this chunk of paternal hard sense in reply: "What is the use of your complaining of mankind? The world as yet owes you nothing. Up to this time you have been simply a recipient of its benefits. Make yourself worthy of a place *here* and you will find one." The project of going to Africa was abandoned.

Dr. Rogers now joined an intimate friend and fellow-student, Dr. Henry Webster, in a partnership to practice medicine at Little Britain, Pa., about two miles north of the Maryland line. But after a few years' experience he abandoned the profession, having found it repugnant to his mental habits and sensitive nature. He returned to Baltimore, and was soon appointed superintendent of the extensive chemical manufactory of Messrs. Tyson and Ellicott.

From this time on Dr. Rogers made pure and applied chemistry his chief concern. The professorship of Chemistry in the

Washington Medical College being offered to him, he hesitated to accept it, thinking he was not sufficiently ready of speech for a lecturer. He finally undertook the work, and, although it was not remunerative, it served to discover the fact that he shared the gift of eloquence which distinguished his brothers. The ice being thus broken, he found it easy to give chemical lectures before the Mechanics' Institute, in Baltimore, and later he lectured also on physics.

Dr. Joseph Carson states in his memoir of Dr. Rogers that it was William B. Rogers who induced his brother to venture upon the career of a college lecturer, and thus relates how it was accomplished: "To convince him that he had nothing to apprehend on that score [lack of fluency], his brother William prevailed upon him to accompany him to the lecture room, and there, placing the future professor behind the desk, constituted himself the audience. The theme was named, which being instantly taken up and amplified upon, the ease and fullness with which he spoke relieved him of his diffidence and apprehension. This was his first effort to lecture, and, like this, all his future performances were without notes or facilities of recollection, except those incident to the arrangement of the topic."

In September, 1830, being then twenty-eight years of age, he married Rachel Smith, of Baltimore, a birthright member of the Society of Friends.

Cincinnati was the residence of Dr. J. B. Rogers from 1835 to 1839, this period being the whole term of existence of the Medical Department of Cincinnati College, in which he had accepted the professorship of Chemistry. The summer vacations of these four years he spent as an assistant to his brother William in fieldwork and chemical investigations on the Geological Survey of Virginia. While in Cincinnati he declined the office of melter and refiner in the branch mint at New Orleans, offered to him by the President of the United States.

Dr. Rogers now, 1840, removed to Philadelphia and became an assistant to his brother Henry, who was the State Geologist of Pennsylvania. He also turned his knowledge of chemistry to account in various other occupations. He was appointed in 1841 lecturer on chemistry in the Philadelphia Medical Institute, then a flourishing summer school, which had been founded by Dr. Nathaniel Chapman. From 1844 to 1847 he was Professor of General Chemistry in the Franklin Institute, of which institution he had become a member when he went to live in Philadelphia. In this period he and his brother Robert compiled a text-book on Chemistry from the Inorganic Chemistry of Dr. Edward Turner and the Organic Chemistry of Dr. William Gregory. It was published in 1846. He also conducted quiz classes of medical stu-

dents. He was for a time Professor of Chemistry in the Franklin Medical College, and represented this institution in the National Medical Convention, held in Philadelphia in 1847, which organized the American Medical Association.

In 1847 he succeeded the celebrated Dr. Robert Hare as Professor of Chemistry in the University of Pennsylvania—a curious coincidence in connection with his father's succeeding Dr. Hare at Williamsburg. In this position he remained until his death, five years later. He was also one of the representatives of the university in the National Convention of 1850 for revising the Pharmacopœia of the United States.

In 1846 he was elected to membership in the American Philosophical Society, and the following year joined the Academy of Natural Sciences of Philadelphia.

Dr. Rogers was of slight frame and never enjoyed robust health. In his latter years he suffered at times from nervous exhaustion and defective nutrition, probably induced by unremitting labor. He died June 15, 1852, leaving a widow, two sons, William B. and Henry A., also a daughter, Mary V. Rogers.

Never favored by prosperity, Dr. Rogers was particularly straitened in circumstances during the first part of his residence in Philadelphia. It was not until he entered upon his last professorship that he received a comfortable salary. The institutions with which he had been connected before were small and weak or came to grief in some way that could not be anticipated. While lack of shrewdness and assertiveness on his own part may have contributed to hinder his advancement, his worth as a teacher is beyond question. He was everywhere esteemed by his colleagues and popular among his students. Dr. Carson said of him, "Disinterested and generous in his relations with the world, mild and conciliating in deportment, open and affable when approached, urbane to every one, his virtues shone conspicuously within the circle of his friends. With his pupils he was sympathizing; he entered cheerfully into their discouragements and difficulties; and those who confided to him received that encouragement and counsel so grateful to the student's feelings. He was emphatically the student's friend."

AT the School of Horticulture, Geneva, Switzerland, fourteen professors are engaged in teaching the various branches of the science, which include floriculture, arboriculture, kitchen gardening, landscape architecture, forest culture, vine dressing, zoölogy, bee raising, botany, chemistry, and metallurgy. A considerable part of the school day is devoted to practical work under the direction of five superintendents.

Editor's Table.

INTELLIGENCE IN THE PUBLIC SERVICE.

A RECENT writer in one of the magazines quotes John Stuart Mill as speaking in one of his letters to the historian Motley of "the fatal belief of your public that anybody is fit for anything." The trouble to which Mill refers is one that dates a long way back. It is not correct to say that in this community or anywhere else the belief prevails that anybody is fit for *anything*. Nobody thinks that anybody is fit to repair his watch, or to fit him with spectacles, or to cut him out a suit of clothes. We all believe in special training and special qualifications when it comes to matters like these; but what democratic communities, from Athens downward, have refused to believe is that any special qualifications are required for the art of political government. It is to be observed that it is political government *only* that is regarded as so simple and trivial a thing. To manage a bank, a railroad, a hotel, is allowed on all hands to require great skill and experience combined with no inconsiderable equipment of moral character; but to step into the Presidency and fill the office satisfactorily does not, it has been expressly stated, call for anything more than commonplace endowments. A little more seems, as a general thing, to be required of members of the Cabinet; but, broadly speaking, Mr. Mill's dictum, if we confine it—as doubtless he meant it to be confined—to politics, is true, that in this country "anybody is considered fit for anything."

What is the source of this most preposterous opinion? It is difficult to give any answer but one: the self-interest and vanity of the populace: self interest, because the unqualified office-seeker does not like to think he might be barred from office by lack of competency; vanity, because the voter who feels a sense of proprietorship in the Government does not like to think that he himself or any person he might recommend is not "good enough" for any office in the Government. Of course, it has to be admitted—though somewhat grudgingly—that offices requiring technical knowledge in connection with this or that branch of science can not be filled by persons destitute of such knowledge; but it is always a consolation to think that the most ignorant citizen could acceptably fill some higher office in which he would have power to make the men of science step round.

Fortunately, there are laws operating even in the political world which to some extent antagonize false theories. It may be sound democratic doctrine that any citizen is fit for any office; but when it has come to filling the offices, in some mysterious way conspicuously unfit individuals have not infrequently been ruled out. No one, of course, would venture to say that they were ruled out for lack of intellectual qualification; but they have been ruled out all the same, and left to wonder how it was that their candidature was not successful. In a few cases conspicuously fit candidates have been selected, to the great advantage of the public interests concerned.

The strongest proof, however, that there is a certain tendency in things to nullify wrong theories is the prog-

ress which this country has made in the matter of civil-service reform, and this in the teeth of the strongest opposition which could be made in the interest of the old, unregenerate idea that all offices were on a level with the abilities of the first comer, provided only he had the necessary certificates of political service. A powerful New York journal thought at one time to sneer the reform out of existence; but, the more it sneered, the more the idea seemed to gain in strength, and the more firmly it rooted itself in our system of government. This would seem to prove that the citizens of this country, however they might outwardly countenance the notion that anybody was fit for anything, felt in their hearts that the doctrine was a false and fraudulent one. That is precisely what it was and is; and the falsehood and the fraud have in many ways cost this country dear. It needs perhaps a little experience of administrative work in order to appreciate fully the difference in efficiency between a man in whom experience is united to intelligence and seriousness of purpose, and who is thus enabled to put a stamp of thoroughness on all he does, and one of mediocre or inferior intelligence who simply thinks he is big enough for any office, and that one way of doing a thing is about as good as another. It is always at the expense of the public that the latter type of official practices his crude and ignorant methods; but in general, though the shoe is sure to pinch, it is difficult, if not impossible, for the public to tell just where they are pinched or where the responsibility rests. We may set it down, however, for an unmistakable fact that, in so far as governmental methods are marked by inefficiency and lack of intelligence, the origin of the trouble lies in the idea to which we referred at the outset, that "anybody is fit for anything." The man who employs a blacksmith as a dentist when more skilled assistance is available has only himself to thank if he suffers a few unnecessary pangs; and precisely so in the public service: if we put into office men who lack the essential qualifications for their positions, we must take what we can get and, if not be thankful, at least have the sense to place the responsibility upon the right shoulders—that is, upon our own.

DECIMAL COMPUTATION.

THE article from the pen of Mr. Herbert Spencer which we publish in this number will, we believe, open the eyes of many of our readers to the fact that whatever the advantages of the metric system of measurement now so widely used in Europe may be, there are very considerable objections to its introduction in countries where it has not yet been established. Mr. Spencer, as usual, states his case in a very comprehensive manner; and it would be difficult to add anything to the arguments he brings forward. He makes it very clear that the only valid claim that can be urged on behalf of the metric system is that, on account of its correspondence with the existing system of notation, values expressed therein admit of easier arithmetical treatment than values expressed according to other methods. He shows, however, that this is quite a limited advantage. Express your values in the metric or decimal system, and you can add or multiply them with great facility; but the difficulty lies in getting those particular fractional values expressed which we have most occasion to use in everyday life, and which it is the instinctive habit of our minds to deal with—such as thirds, fourths, sixths,

eighths. It is needless, however, to repeat here what is so fully stated in Mr. Spencer's article. He admits the great convenience of the decimal system for the expression of strictly scientific values, as in giving the results of chemical analysis. In this case no other system than one which expresses results to the minutest fraction would be of any avail. But he objects, that this ready applicability to scientific measurements, which has led scientific men to advocate its universal employment, is no advantage for purposes of trade, where easy divisibility is of the first importance. The question is whether it is or is not desirable to introduce standards of measurement which can only be subdivided decimally, and banish our present standards, which admit of more convenient subdivision into well-known and definite aliquot parts.

We quite agree with the writer that such a change as this should not be hastily made, and we think he has done well in marshaling the difficulties and disadvantages with which it would be attended. The standards of measurement which every nation possesses are part of its history, and their long survival is at least *prima facie* evidence of their utility and convenience. If we take the particular instance which the word "metric" itself suggests, it seems to us we are better off with such familiar and convenient measures as the yard, the foot, the inch, and the subdivisions of the latter into halves, quarters, eighths, sixteenths, etc., than we should be with the metre divided into centimetres and millimetres—that is, into hundredths and thousandths. What the subject wants, however, is discussion from every point of view. The question is one in regard to which no single interest should have a decisive voice; yet there is always danger, when a change is mooted, that it will be carried through the vigorous insistence of those who want it, and to whom, perhaps, it would be advantageous, and the lack of contrary effort on the part of a much larger number to whom it would not be beneficial but who are not sufficiently alive to their interest in the matter.

Mr. Spencer hints at a possible change to be made in our system of notation involving the use of two additional digits and making twelve instead of ten the basic multiple of progression. He does not expect it can be introduced for generations to come. That if introduced it would have the specific advantages he mentions can not be doubted; but we agree with him that the practical difficulties in the way of the change are enormous, and that we must be content to regard it rather as a shadowy possibility for the future than as a scheme offering any promise of early fruition.

THE PROVINCE OF SCIENCE.

DR. ROMANES'S assertion* that "if a little knowledge of physiology and a little knowledge of psychology dispose men to atheism, a deeper knowledge of both and, still more, a deeper thought upon their relations to one another will lead men back to some form of religion," is sure of unquestioning welcome in certain quarters; but the earnest seeker after truth will care little to hear that George John Romanes or Francis Bacon "thought thus," although he may care a great deal to learn what led these writers to their belief.

The question which thoughtful men will wish to ask Romanes is whether his "religion" has any more

* Mind and Motion and Monism. By the late George John Romanes. Longmans, Green & Co. 1895.

basis in science than his "atheism"; whether either of them finds any warrant in our knowledge of Nature; whether both may not be equally outside its limits. Most modern thinkers and writers on the principles of science agree in the declaration that the mind of man has not yet attained to knowledge of causes; that it has done no more than to discover a little of the *order* of Nature.

While we may, if we choose, call the series of *events* which make up this order a series of *effects*, nothing seems more certain than that we have not yet succeeded in passing over from them to any reality behind them; that the reason why they occur in one order rather than another is a problem which is as yet absolutely unsolved.

Romanes quotes, with approval which all must share, Tyndall's declaration that "the passage from the physics of the brain to the corresponding facts of consciousness is unthinkable. Granted that a definite thought and a definite molecular action in the brain occur simultaneously, we do not possess the intellectual organ, nor apparently any rudiments of the organ, which would enable us to pass, by a process of reasoning, from the one phenomenon to the other. They appear together, but we do not know why." So far as our present knowledge of the powers of the human mind goes, we must agree with Romanes that Tyndall's assertion is most unquestionably true. Whether or not it is the whole truth is a different question, and we must ask whether we are any more able to pass from one physical event to another physical event, or from one mental event to another mental event, than we are able to pass from a physical to a mental event. Can we say of any of them anything more than that "they appear together, but that we do not know why"?

Romanes tells us that our questions about the nature of the relation between material changes and mental changes admit of only seven possible answers, all of which he enumerates, and four of which we quote: I. The mental changes may cause the material changes (spiritualism). II. The material changes may cause the mental changes (materialism). III. There may be no causation either way, because the association may be only a phenomenal association—the two apparently diverse classes of phenomena being really one and the same (monism). VII. Whether or not there be any causation either way, the association may be one which is necessarily beyond the power of the human mind to explain.

The aim of Romanes's book is to show that six of these seven hypotheses are untenable, and that, since only seven are possible, the seventh, No. III, must be the truth; although it is clear that, if the human mind has as yet discovered nothing but the *order* of Nature, and has not attained to knowledge of causes, there must be still another point of view. We may declare that we know nothing whatever about the matter; not even enough to warrant the assertion that it is necessarily beyond the power of the human mind to explain. Romanes holds that this way of looking at the subject does not deserve to be regarded as an hypothesis at all; but while it may not be an hypothesis, it may nevertheless be that still more stubborn thing, a fact. Those who agree that it is a fact will feel no more vital interest in Romanes's monism than in materialism or idealism or spiritualism, for they will perceive that all these attempts to reach reality by means of our present knowledge of Nature

are equally vain and premature; and they will also perceive that science gives no better warrant for the "religion" to which Romanes has been led than it gives for the "atheism" which he has outgrown. We hope his fascinating book will find many readers, for it will give them the pleasure which is found in all strong and vivid works of the imagination; although we refrain from detailed discussion of its ingenious arguments, for the reason that we are sure no thoughtful student can mistake it for a contribution to knowledge.

If certain enthusiastic students of Nature have been carried away into materialism by the triumphs which modern science has achieved through the use of the symbolism of matter and motion, they can not complain that there has been any lack of warning. The most profound and cautious thinkers of our century have never ceased to insist that our conceptions of matter and motion are nothing more than symbols; and that, so far as knowledge of any reality behind them is concerned, they might as well be called x and y. General recognition of this truth is now producing a reaction which seems, to these zealous believers, to drive them out of their materialism into some other system of philosophy; but before they rush from one extreme to another, they should ask themselves whether this revolution will bring them any nearer to the solid rock of certainty than they were before. No one who is familiar with the work of our greatest intellectual leaders can find anything novel in Romanes's declaration that "when we speak of matter in motion we do not at all know what it is that moves, nor do we know at all what it is that we mean by motion"; although we must ask the followers of Romanes whether we know anything more about the essence of mind than we know about the essence of matter, and whether we can say anything more of our mental changes than that "they appear together, but we do not know why."

Prof. Ostwald tells us in his address on "The Failure of Scientific Materialism"* that "every scientific thinker, from the mathematician to the practicing physician, would sum up his view, in answer to the question how he supposes the world is intrinsically constituted, by saying that the universe is composed of atoms in motion, and that the atoms and the forces acting between them are the ultimate realities of which individual phenomena consist." Whatever the German frame of mind may be, we are disposed to believe that many Englishmen and Americans, if asked "What are the ultimate realities of which individual phenomena consist?" would answer that they do not know. We believe there would be no difficulty in finding many eminent men of science who have refused to have anything more to do with materialism than to make use of its symbols, so far as they have proved useful. So long ago as 1868, Huxley tells us† that he *shares with some of the most thoughtful men with whom he is acquainted* the union of materialistic terminology with the repudiation of materialistic philosophy; that he individually is no materialist, but, on the contrary, believes materialism to involve grave philosophical error. Ostwald seems to have come, somewhat late in the day, to the point of view from which Huxley's most thoughtful acquaintances contemplated materialism in 1868; but, unlike Huxley, he proposes a substitute, and seeks to show that

* See translation in Popular Science Monthly for March, 1896.

† Collected Essays, I, iii, 155.

"the predicate of reality can be ascribed only to energy."

Since it is generally admitted that, whatever the unknown reality may be, our conception of energy is a projection into the external world of the feeling of resistance and effort which accompanies our own voluntary actions, the question whether "the predicate of reality can be ascribed to energy" leads us at once to the preliminary question whether volition is real or phenomenal. If the interminable discussion on the freedom of the will, which has exercised the most acute intellects of our race for many centuries, teaches anything, it teaches that science is not yet able to answer the question whether the "predicate of reality" is or is not to be ascribed to volition; and that, in the present state of our knowledge of Nature, Ostwald's substitute for materialism is no better and no worse than the system which he seeks to displace and supplant.

THOSE BLESSED X RAYS.

WE were quite prepared for it, as we mentioned last month; so it was no surprise to us to read the following in The Herald and Presbyter of a recent date, the reference therein being to Röntgen's discovery: "For one thing, it corroborates, so far as any material experiment can, Paul's doctrine of the spiritual body as now existing in man. It proves, as far as any experiment can prove, that a truer body, a body of which the phenomenal body is but the clothing, may now reside within us, and which (*sic*) awaits the moment of its unclothing, which we call death, to set it free." We are further told in the same article that the discovery in question "makes clear to the unscientific mind what Stuart (*sic*) and Tait announced, that matter in one state has no power to exclude matter in another and more refined state," and that we must therefore now be prepared to believe "that two particles of matter can and do occupy the same space at the same time."

A very few remarks on this piece of special pleading must suffice on the present occasion.

1. "Paul's doctrine of the spiritual body." Why this doctrine should be called Paul's it is hard to understand, seeing that it is encountered in every quarter of the globe among nations and tribes of almost every grade of civilization. In the Odyssey Ulysses talks to the "spiritual body" of Achilles in the nether world, a body which was "set free" when the natural body of the hero was slain. It is difficult, therefore, to see why Paul rather than Homer should be mentioned as having his "doctrine" confirmed by the discovery of the X rays.

2. Paul's doctrine, however, was not that there *may be* a spiritual body within—but, after all, why *within* more than *without*?—the natural body, but that there *is* such a body; whereas Röntgen, according even to the writer we are quoting, only proves that there *may be* one. A thousand proofs, however, that a thing may be does not advance us one whit toward proving that it is. Moreover, Röntgen's discovery does not point any more in the direction of a spiritual body within our bodies than it does in the direction of a spiritual body within cats, or dogs, or sheep, or trees, or stones.

3. Strictly speaking, Röntgen's discovery proves nothing about bodies in general that has not been known for centuries. That light can pass through solid bodies even of great thickness and density has been the common experience of mankind ever since the first transparent substance was discovered. Röntgen has merely discovered that substances which are not penetrable by ordinary

light rays are penetrable by other rays produced by electrical discharges in a very attenuated gaseous medium. How we are to derive any confirmation of the existence of a spiritual body from the action of these rays which could not equally have been drawn from the action of ordinary light rays in traversing such dense substances as glass and various crystals, is a question which it would probably puzzle the Herald and Presbyter to answer.

4. As to the possibility of two particles of matter occupying the same space at the same time, any one who chooses to indulge that pleasing and profitable fancy can do so; but how it can help in the present emergency we do not see. Any difficulty which there may have been about admitting the doctrine of a spiritual body has not arisen in the least from our ordinary conceptions of matter, because we know perfectly well, and have known for so long that the memory of man runneth not to the contrary, that one form of matter may be permeated by another form —the metals by gases, for example— in varying volumes. The trouble has not been to find room for the spiritual body in the natural body, but to find something more than a mere assertion of its existence at all or anywhere. This, unfortunately, is a difficulty which some persons can not be brought to understand: give them leave to think that what they want to believe is not impossible, and presto, they consider it proved. We have no objection in the world to the theory, whether Paul's, or Homer's, or Plato's, of a spiritual body; but we do think it a little hard that because a laborious experimenter like Röntgen has brought to light a new property of radiant energy—while, like a well-trained man of science, he only affirms what he has been able to demonstrate—others should rush in and insist that, without being aware of it, he has bolstered up some doctrine of theirs for which not one scintilla of evidence can be given. As this kind of thing, however, evidently can not be helped, we can only hope, as we said before, that in some mysterious way it may serve a useful purpose. It is better, on the whole, that each successive advance of science should be acclaimed as a confirmation of orthodoxy than denounced as a new manifestation of impiety; and certainly better far the treatment given to Röntgen and his tubes and screens than that meted out to Galileo and his telescope.

Scientific Literature.

SPECIAL BOOKS.

THE first volume of the Criminology Series was the result of a special research; the second has a broader and more philosophical scope.* Obviously the collection and choice of data lie at the base of any reasoning in criminology. Considerable attention has been paid to such data as anatomical, physiological, and psychological anomalies of criminals. These, Prof. *Ferri* is convinced, are of value almost solely with respect to born criminals. He makes five classes of criminals: criminal madmen, born

* Criminal Sociology. By Enrico Ferri. Pp. 284, 12mo. New York: D. Appleton & Co. Price $1.50.

criminals, criminals by contracted habits, occasional criminals, and criminals by passion. Those in the last three classes he deems largely the victims of circumstances. He looks to criminal statistics for considerable light on the sociological side of criminality, and finds as the most conspicuous general phenomenon that they exhibit "the steadiness of the gravest forms of crime side by side with the continuous increase of slighter offenses." At the same time there are yearly fluctuations in the several kinds of offenses corresponding to seasons of great or small harvests, excessive heat or cold, political or commercial disturbance, etc. On this correspondence of the amount of criminality to the environment Prof. Ferri bases his "law of criminal saturation," which contradicts Quetelet's dictum as to a regular budget of crime. From this law it follows that the penalties hitherto regarded as the best remedies for crime can not be effectual. Our author, therefore, recommends what may be called "penal substitutes," the aim of which would be to reduce the factors of crime. As ways in which society can be protected indirectly from aggression he instances such devices as the shifting of taxes which tempt to fraud, the adaptation of governments to the people they control, scientific means for the detection of crime, wise legislation in regard to marriage and inheritance, scientific education, and the abolition of unwholesome amusements. The latter half of the volume is of most popular interest, as it is devoted to practical reforms. Among the changes that Prof. Ferri advocates are the general use of the Scotch verdict of "Not proven" in cases where neither guilt nor innocence is established, indemnification for judicial errors, the direction of criminal trials, not to appraising the culpability of the prisoner for a particular act, but to ascertaining to what type of criminals he belongs, the abolition of the jury, except in the trial of crimes of the political and social order, the employment of various grades of segregation of the criminal with indeterminate sentences, the commitment of insane criminals to asylums, add the abolition of the death penalty. Many other allied topics are discussed incidentally. The above constitutes what Ferri regards as a defensive system of criminal administration which society should substitute for its present punitive system.

We have had a life of Agassiz as a man, we now have him placed before us both as a man and a scientist by one of his scientific associates and fellow-countrymen.* In telling the story of Agassiz's life Prof. *Marcou* has made use of materials collected from many sources, including much obtained from Agassiz's European friends and associates. All of Agassiz's letters that he inserts, some twenty-five or thirty, were written in French and stand in the original language. So also do Agassiz's presidential address on the ice age, delivered before the Helvetic Society, which fills nineteen pages of small type, and the six pages of extracts from De Charpentier's first paper on erratic bowlders, the author believing that all these documents would suffer too much by translation. Our author is not one of those who write eulogy and call it biography. He lets both the well rounded and the less rounded sides of his subject's character be seen. While not depicting him as a demigod, Prof. Marcou has credited Agassiz with talents sufficient to accomplish the labors on which his fame rests.

* Life, Letters, and Works of Louis Agassiz. By Jules Marcou. Two Volumes, 12mo. New York and London: Macmillan & Co. Price, $4.

"Agassiz was capricious in the extreme," he says, "very versatile, attracted easily by any new object or subject, and he had the faculty of almost completely forgetting works half done or only sketched. He lacked persistence and steadiness at work requiring long and difficult observations. . . . That something sternly practical mingled with Agassiz's habitual idealism was well proved by his museum. He did not carry it out entirely as he proposed to do at the start, but had he lived twenty years longer his ideal museum would have become a reality. . . . Notwithstanding these serious defects, it is impossible not to admire his great scientific intelligence, and not to recognize his immense scientific force. No one was such an able instigator of scientific researches. He had a magnetic power, and he used it constantly, whatever the subject to be investigated might be. His two principal passions in natural history were teaching and collecting specimens. As a teacher he was unrivaled and unique. . . . As to his other passion, that of collecting specimens and organizing museums, he was a man of wonderful resource." Agassiz's moral traits are also given with much fullness. Many of his characteristics were racial. As his biographer well says, "Agassiz's remarkable personality can not be properly understood without taking into account the strength of his French nature." The Anglo-Saxon reader especially should bear this in mind. Prof. Marcou does not hesitate to go into the various controversies to which Agassiz was a party and to apportion praise and blame according to his judgment. The function of a critic seems to be rather attractive to him, for he goes out of his way to point out defects in Mrs. Agassiz's life of her husband. The word "Works" in the title of this book refers to a list of Agassiz's works, reaching 425 titles, which is appended to Volume II. A list of biographical articles and volumes on Agassiz forms another appendix, and a list of portraits, medals, tablets, etc., still another. A profile portrait and several other illustrations are given.

Two series of books which promise to be very useful to the scientific horticulturist and agriculturist are being issued by the Macmillans. In the Gardencraft Series, we have already noticed The Horticulturist's Rule-book, by Prof. *L. H. Bailey*, and the second of the series, also by Prof. Bailey, is now before us.* Our author treats his subject both philosophically and practically. He first points out some of the causes of variation in plants, and shows that man is only rarely the direct means of originating varieties, but that his work consists in selecting and fixing those that he prefers. In treating of crossing, Prof. Bailey insists on a distinction between the cross proper—i. e., the product from a union of two varieties of the same species—and the hybrid, or product of a union between different species. He tells what benefits may be expected from crossing, and endeavors to prevent too great expectations from hybridizing. The practical portions of the volume are the third and fifth chapters. In the former are given fifteen rules which should govern the breeding of plant-crosses, with the reasons for them. Among these we find such maxims as the following: "Avoid striving after features which are antagonistic or foreign to the species or genus with which you are working." "Breed for one thing at a time." "Establish the ideal of the desired variety firmly in the mind

* Plant-breeding. By L. H. Bailey. Pp. 293, 12mo. London and New York: Macmillan & Co. Price, $1.

before any attempt is made at plant-breeding." "Even when the desired variety is obtained, it must be kept up to the standard by constant attention to selection." The last chapter consists of directions for the pollination of flowers to secure crossing, with illustrations. There are also extended extracts from Verlot on varieties of ornamental plants, Carrière on bud-varieties, and Focke on characteristics of crosses. A glossary is appended.

The Rural Science Series, edited by Prof. Bailey, opens with a volume on spraying.* From the author's chapter on the early history of liquid applications, it appears that plants have been sprinkled with noxious or irritating substances in order to destroy insects for a century, and very likely much longer. The operation known as spraying, however, has not been practiced for more than ten or fifteen years. The early gardeners seemed to think that anything disagreeable to man would be destructive to insects, and Mr. *Lodeman* gives a number of their recipes evidently based on this idea. Continuing his history, he narrates the introduction of the Bordeaux mixture, the kerosene emulsion, Paris green, London purple, and the other principal insecticides and fungicides now used, and gives the various methods of spraying employed in different countries and in different parts of the United States. Another historical chapter records the progress in appliances, from the liquid in a bucket and a whisk broom to sprinkle it with, up to the small towers on carts on the top of which men armed with hose pipes go gunning for codlin moths, curculios, canker-worms, and such like game. In another chapter he gives formulas for a large number of preparations used in spraying, and, in still another, specific directions for treating the chief cultivated plants, from almond to willow. He discusses also the action of insecticides and fungicides not only upon the pests that they are directed against, but also upon the host-plant, the crop yielded by it, and the soil in which it grows. There are eighty-six cuts and a portrait of M. Millardet, who introduced the Bordeaux mixture. Both volumes are adequately indexed.

We have here not the gossip and superficial impressions of a sight-seer, nor yet a volume of laborious measurements and close reasoning. *Greenland Icefields* is a description of natural features and inhabitants by one who is not too much engrossed in his science when he visits a strange region to notice and write down matters of interest to less scientific mortals.† With this descriptive matter is joined a new discussion of the causes of the ice age, embodied in several chapters contributed by Prof. *Upham*. Prof. *Wright* tells us first about the ice of the Labrador Current, which was brought forcibly to his attention by the steamer on which he went to Greenland running squarely against an iceberg. This mishap necessitated a stop on the coast of Labrador, and enabled him to gather may interesting observations on the settlements and the Eskimos of this coast. He records also some observations on the Spitzbergen ice that comes down through Davis Strait. Greenland was finally reached at Sukkertoppen, on the western coast, in latitude 65° 30′. Prof. Wright gives us not only the incidents of his journeys in this far northern land, but also the chief features

* The Spraying of Plants. By E. G. Lodeman. Pp. 399, 12mo. London and New York: Macmillan & Co. Price, $1.

† Greenland Icefields and Life in the North Atlantic. By G. Frederick Wright and Warren Upham. Pp. 407, 12mo. New York: D. Appleton & Co. Price, $2.

of the twelve districts into which the western coast strip is divided, some account of the customs and character of the Eskimos, and a historical sketch of the explorations and administration of Europeans in Greenland. His descriptive matter is frequently enlivened by anecdotes, and the text is illustrated by reproductions of many photographic views of persons and places.

From materials furnished by Prof. Wright and other explorers, Prof. Upham has prepared descriptions of the plants and the animals of Greenland and of the inland ice sheet. He also devotes a chapter to tracing the continental changes of level of the Pleistocene period. With this material as a basis, he proceeds to discuss the causes of the ice age, giving the theories that have been put forth to account for the great extension of the ice, and explaining the difference of opinion among glacialists as to whether there were one or more epochs of glaciation. The authors of this book hold to the theory that the ice sheets were due to extensive uplifts of the land forming plateaus which received snow throughout the year. In another chapter the successive stages of the ice age are traced as revealed by their marginal moraines and other deposits. In conclusion, Prof. Wright summarizes the chief facts relating to Greenland's mantle of ice, and to the life of its inhabitants, who seem to be admirably adapted to their surroundings and happy in them.

GENERAL NOTICES.

PALEONTOLOGY is presented from a point of view somewhat different from the ordinary in a book which Prof. *Williams*, of Yale University, has just published.* The author says that while there are no end of books on evolution, and modern biologists seem content to assume that some theory of evolution is true, and although the sociologist, the moralist, and the theologian are basing their theories about man on the "working hypothesis" of the naturalist, as if "law and gospel," it seems to have escaped serious attention that we have open for study a genuine record of the actual evolution of organisms, extending from near the beginning of life up to the present time. The geologist does not ask what is the theory of evolution, but what are the facts of evolution. The book is intended simply as an introduction to an already broad field, which is rapidly widening. The history of organisms is first taken up and treated quite fully. The next two chapters consist of a history of the making of the geological time scale, and a general consideration of its divisions. The naming and the fossils of stratified rocks, the nature of fossils and their geographical distribution next occupy attention. What is a species? What is an organism? and What is the origin of species? are the elementary but important questions answered in the next three chapters. The principles of natural history, classification, and the types of construction in the animal kingdom, occupy Chapters XI and XII. Phylogenesis in classification, the acquirement of characters of generic or higher rank, what is evolved in evolution, the modification of generic characters, and the plasticity and permanency of characters in the history of organisms, bring us to the eighteenth chapter, which takes up the cephalopods, to illustrate the rate of morphological differentiation in a genetic series. In Chapter XIX the ammonids are studied in a similar manner to illustrate the progressive modification of an extrinsic character. The last two chapters —one on the laws of evolution, as emphasized by a study of the geological history of organisms, and finally the philosophical conclusions regarding the causes determining the course of evolution, are in the nature of a general summary of the whole subject.

* Geological Biology: An Introduction to the Geological History of Organisms. By H. Slater Williams. New York: Henry Holt & Co. Pp. 302, 8vo. Price, $2.80.

A valuable series of archæological investigations is chronicled in a tasteful 8vo entitled *The Hill Caves of Yucatan*.* The author, who is Curator of the Museum of American and Prehistoric Archæology at the University of Pennsylvania, had had his eye, so to speak, on the Central American hill caves for several years. The expedition was at last made possible by the munificence of Mr. J. W. Corwith, of Chicago, its purpose being to search for new evidence of man's antiquity in the caves of Central America. The party landed at Progreso, and rapidly made their way into the interior. The coralline and porous Mesozoic limestone of that part of Yucatan had not been upheaved or faulted, and, save for the waves of the hill ridges, lay as it was deposited. The caves were found to open vertically down into the ground like wells, the shaft having evidently been formed by the natural weathering down of a level rock surface until a hole in the roof of the cave was produced. These caves, of which a number were examined, were found in some cases to contain rude inscriptions on the walls, in all cases a large number of broken potsherds, and in the excavations conducted in the layers of rubbish which made up the floor of the caverns, charcoal and ashes, mixed with potsherds of many makes and some bones, but no arrowheads, spear points, or even flakes of hornstone. Some human bones scattered in the rubbish indicated that the old inhabitants of Yucatan practiced cannibalism. Taken as a whole, the antiquities show us the ancient cave visitor as an agriculturist rather than a hunter, although he seems not to have possessed domestic animals. The author, in closing, says: "An earlier people visiting Yucatan under its present topographical conditions must needs have left traces in the caves; because the undisturbed earth beneath the culture layer discovered always failed to show trace of any deeper, older, or more primitive human visitor, the conclusion was that no such earlier people had seen the region while its stony hills, its torrid plain, and its damp caves were as they now are." The book, aside from its archæological value, is of interest as giving a picture of the geography and people of that portion of Yucatan. It is very well illustrated.

One of the most beneficent services rendered by modern science consists in supplying a basis of exact knowledge for those necessary arts that have been carried on by empiric methods for centuries. Among the most ancient of these arts is that of utilizing the milk of our flocks and herds, for which a scientific basis has only recently become available. It is the purpose of the book before us * to give the chemistry and bacteriology of the several processes of the dairy. The author first describes briefly the cow's udder and its process of secretion, and then passes to the composition of milk, giving the percentage composition of the milk of a number of animals, with a discussion of the variations observed, and a table of the legal standards in England and many of the United States. After setting forth some of the causes that influence the yield and quality of milk, he passes to the subject on which science has been able to give the most practical knowledge to the dairyman—bacteria. It is bacteria that cause milk to become ropy or viscous to turn blue, red, or yellow, to acquire a bitter taste, and to undergo fermentative curdling. Bacteria also are indispensable in the making of butter and cheese. Pure cultures of these organisms are used in dairies all over the north of Europe for ripening cream, and our author urges his fellow-countrymen not to be behind the foreigner in this matter. After discussing the essential features of the formation of butter and cheese, including the process of churning and the action of rennet, he gives the usual modes of testing milk, and closes with a chapter on milk as a food.

Convinced that throughout Europe there must have existed systems of picture writing such as survive among primitive races, Mr. *Arthur J. Evans*, the keeper of the Ashmolean Museum, has made extended explorations in Crete which have brought to light

* The Hill Caves of Yucatan. By Henry C. Mercer. Philadelphia: J. B. Lippincott Co. Pp. 183. Price, $2.

* Milk: its Nature and Composition. By C. M. Aikman. Pp. 180, 12mo. London: Adam & Charles Black. New York: Macmillan & Co. Price, $1.25.

not only a large number of carvings of apparent pictographic character, but also many simpler markings which seem to show the existence of a system of linear writing more ancient than that of the Phœnicians. In a volume entitled *Cretan Pictographs and Præ-Phœnician Script* (London: Quaritch; New York: Putnams) he has described a large number of these carvings, together with others from the sepulchral deposit near Phæstos, in the Peloponnese. The work is illustrated with one hundred and thirty-nine figures and several plates, including a reconstruction of a Mycenean ceiling decoration in colors.

A very practical and without doubt a unique book is the *Laboratory Manual of Inorganic Preparations*, of *H. T. Vulté* and *George M. S. Neustadt* (Peck, $2). It tells the student how to prepare a large number of the inorganic reagents used in the laboratory, the processes ranging in difficulty from the distilling of water and the preparing of oxygen and hydrogen gases to the preparation of hydrazine, carbon oxysulphide, and acid or alkaline normal solutions. The number of substances included is, apparently, over two hundred. In the recovery of substances that have been used in experiments and in the preparation of C. P. reagents from chemicals of commercial grade the authors are convinced that not only can much needless waste be prevented, but that much knowledge of value to the student can be acquired.

Of two recent numbers of *The Journal of the College of Science* of the Japanese Imperial University, one, being Volume VIII, Part II, contains five papers relating to biological subjects, accompanied by nine plates; and the other, Volume IX, Part I, comprises ten physical and chemical papers, with five plates.

In his monograph on *The Physical Geography of Southern New England* (American Book Co., 20 cents), Prof. *William M. Davis* presents evidence to show that the region in question is an old peneplain which has had a slanting uplift. In accordance with this theory, he accounts for the mountains that stand out from or rise above the New England upland and for the valleys that interrupt it. The paper contains many suggestions for the genuine scientific teaching of geography. The physiographic development of *The Southern Appalachians* is set forth in a similar essay by *C. W. Hayes*. Both publications are numbers of the first volume of National Geographic Monographs.

Under the title *The Climatology and Physical Features of Maryland*, the Maryland State Weather Service has issued its first biennial report, covering the years 1892 and 1893. The document includes sketches of the topography and geology of the State and general descriptions of its soils and climate. Monthly summaries of the weather and a summary of the weekly weather crop bulletins issued during these two years are included, while in tabular form the reports of observers are given. There are five maps, showing the annual and seasonal temperature and precipitation in Maryland and Delaware.

A quarto pamphlet of *Observation Blanks in Physics*, prepared by Prof. *William C. A. Hammel*, has been issued recently (American Book Co., 30 cents). These blanks contain directions for fifty-four simple experiments relating to air, liquids, and heat, with blank lines for observation, inference, name, date, instructor's indorsement, etc. There are also figures of the parts of the apparatus required, many of the articles being household utensils.

We have already called attention to the series of pamphlet guides to New England natural history which is being issued by *Edward Knobel*. The one now before us is devoted to *The Night Moths of New England* (Whidden, 50 cents), and gives the name, size, and colors of five hundred species with figures of nearly all of them. The species are arranged in seven groups, each with a brief key, and there are three pages of general description.

There is substantial evidence that science is not neglected on the Pacific coast in the eight-hundred-page volume of *Proceedings of the California Academy of Sciences*, which constitutes Part I of Volume V of this publication. Among the more extended monographs which it contains are a Review of the Reptiles of Lower California, by John Van Denburgh; California Water Birds, by Leverett M. Loomis; Neocene Stratigraphy of

the Santa Cruz Mountains, by George H. Ashley; Fishes of Sinaloa, by David Starr Jordan; and Contributions to Western Botany, by Marcus E. Jones. Entomology, conchology, zoölogy, and paleontology are also represented. The volume is accompanied by a frontispiece and seventy-four other plates.

The fourteenth volume of *Transactions of the New York Academy of Sciences* testifies to considerable activity during the year 1894–'95. This volume contains papers on geological subjects by Arthur Hollick, J. F. Kemp, G. F. Matthew, W. D. Matthew, and Heinrich Ries; on biological subjects by Gary N. Calkins, Harrison G. Dyar, and George S. Huntington; while chemistry is represented by Bohuslav Brauner, botany by N. L. Britton and T. H. Kearny, Jr., astronomy by Herman S. Davis and J. K. Rees, mineralogy by G. F. Kunz, and physics by R. A. Millikan. Forty-nine plates accompany these papers. A considerable number of papers that were read during the season either appear elsewhere or have not been published.

Again *Wurtz's Elements of Modern Chemistry* comes to us in a revised (the fifth American) edition (Lippincott, $1.80). Dr. *Greene*, the translator, has associated Dr. *H. F. Keller* with himself in this revision and enlargement, which is designed to bring the book thoroughly up to date. The volume now consists of 808 duodecimo pages, and contains 136 cuts.

Bulletin No. 119 of the U. S. Geological Survey is *A Geological Reconnoissance in Northwest Wyoming*, by *George H. Eldridge* (Geological Survey, 10 cents). It gives a sketch of the topography and general geology of the region, and points out the chief features of its economic geology. First among its useful minerals is a fair quality of coal; petroleum, building stone, brick clays, and a small quantity of gold are also found.

In a treatise entitled *The Constitution and Functions of Gases, the Nature of Radiance, and the Law of Radiation*, the author, *Severinus J. Corrigan*, gives a technical presentation of his theory of gases, the basal concept of which is that the atoms of which each molecule of gas is composed revolve about the center of the molecule. He holds that his theory enables him to demonstrate the existence of some heretofore unknown properties and functions of gases, to determine the probable nature and the properties of the luminiferous ether and the effective temperature of the sun, and to indicate the probable origin of all thermal, electric, and magnetic forces. (Printed by the Pioneer Press, St. Paul.)

A problem which is receiving increasing attention of late years, namely, what to read, is considered by *W. M. Griswold* in *A Descriptive List of Books for the Young* (the author, Cambridge, Mass.). Biography, Geography, History, Exploration, Natural History, Poetry and Fiction, Amusements and Occupations, and Literature are the chapter headings. "Natural Science" is disposed of in one page, seven works being recommended. Considering the broad field which this title is usually supposed to cover, the treatment seems a trifle inadequate. That branch of knowledge which has produced the steam engine, the electric light, the telephone, the phonograph, the printing press, modern astronomy, and chemistry, which is supplying material every day tending toward solutions of some of the still numerous unsolved problems of existence—in fact, which is the great motive force behind modern civilization—ought certainly to be represented by more than one page in a list that gives thirty-three pages to fiction.

Among the many desirable winter resorts which are readily accessible to the inhabitant of the eastern United States, there is perhaps none in which more natural beauty and historic interest are combined with an equable temperature than the Windward Islands. It was on one of them that Columbus first set foot in the New World, and since then they have had a most varied and unique history. In a little book of descriptive travel, *Cruising among the Caribbees* (Scribners, $1.50), *Charles A. Stoddard*, of the New York Observer, has given an attractive and interesting account of a winter visit to this curious little group. A general description of each island, both as regards topography, industries, and inhabitants, is given "in the rough." Various queer customs and superstitions and bits of myth and folklore are recounted, and the whole is woven in with

anecdote and history in such a skillful way that a hero and heroine seem all that is lacking to make of it a good bit of fiction.

The so-called science of phrenology is set forth at considerable length in a book by *Nelson Sizer*, entitled *How to Study Strangers* (Fowler & Wells, New York). It is a curious hodgepodge of very doubtful inferences clothed in scientific language. The body of the work is made up of portraits and short biographical and descriptive sketches of notable persons, written from the phrenologist's standpoint.

PUBLICATIONS RECEIVED.

Agricultural Experiment Stations. Delaware College: The San José Scale Insect.—Illinois University: Bulletin No. 41. Experiments with Wheat and Oats. Bulletin No. 42. Corn Experiments.—Massachusetts College: Bulletin No. 35. The Agricultural Value of Bone Meal. Bulletin No. 36. Imported Elm-leaf Beetles; Maple Pseudococcus; Abbot Sphinx; San José Scale.—Michigan State College: Fruits at South Haven and at the Agricultural College.—Ohio Station (Wooster): Oats.—Purdue University: Bacteriosis of Carnations; The American Persimmon.—United States Department: The Army Worm; The Carpet Beetle or "Buffalo Moth"; Canker Worms; The Imported Elm-leaf Beetle; Facts and Figures regarding Our Forest Resources Briefly Stated; Forest Fire Legislation in the United States; Work against Insects which Defoliate Shade Trees in Cities and Towns; The Harlequin Cabbage Bug or Calico-back; The Hessian Fly; The Hop-plant Louse; Condensed Information concerning some of the more Important Insecticides; The American Cotton-boll Weevil; Mosquitoes and Fleas; The Pear-tree Psylla; The Rose Chafer; The San José Scale.

American Humane Association. Abstract of Report on Vivisection. Pp. 16.

American Republics. Annual Report of Director of Bureau of, 1895. Pp. 28.

American Society for Prevention of Cruelty to Animals. Thirteenth Annual Report. Pp. 118.

Bulletins, Catalogues, Reports, Reprints, etc. Arthur, J. C. Delayed Germination of Cocklebur. Pp. 9.—Bell, A. G. Growth of the Oral Method of Instructing the Deaf. Pp. 23.—College Catalogues and Announcements. Colorado College: Studies, Vol. VI. Cornell: Announcement of Course of Instruction in the Summer School for Teachers and Advanced Students, July 6 to August 15, 1896. Lafayette: Catalogue, 1895–'96. Lehigh: Courses in Civil Engineering and General Literature. Massachusetts Institute of Technology: Catalogue, 1895–'96, and Annual Report of the President and Treasurer, December 11, 1895. Michigan Mining School: Annual Report of the Director, August 16, 1895. University of Pennsylvania: Circular of Information and Announcements for 1896–'97.—Fowler, Hon. Charles N. Speech on the Free Coinage of Silver.—Gilbert, G. K. Presidential Address before Geological Society of Washington, 1895.—Hodge, F. W. Pueblo Snake Ceremonials.—Home Study. A Monthly Elementary Journal of Engineering. 15 cents; $1.50.—Howard, L. O. The Grass and Grain Joint Worm Flies and their Allies. (Technical Series No 2, United States Department of Agriculture.) Pp. 24—Johns Hopkins University: Circular, Vol. XV, No. 123. Pp. 10.—Labor, Bulletin of Department of. No. 8. March, 1896. Pp. 111.—MacDougal, D. T. A Contribution to the Physiology of the Root Tubers of Isopyrum Biternatum (Raf.), Torr. and Gray. From Minnesota Botanical Studies.—Nashville, Tenn., Board of Health. Twenty-first Annual Report of Health Officer to, for Year ending December 31, 1895.—New Jersey Geological Survey. Report on Forestry. Pp. 88.—Philadelphia Academy of Natural Sciences, Proceedings of. Pp. 105 to 200.—St. Laurent, C. F. Germanization and Americanization compared. Pp. 20.—University of the State of New York. Bulletin of the New York State Museum, September, 1895.—Ward, Lester F. Sociology and Physiology. (From American Journal of Sociology, March, 1896.)—White, C. A. Memoir of George Engelmann, M. D. (From vol. iv, Biographical Memoirs National Academy of Sciences.)—Woolman, A. J. Report upon Ichthyological Investigations in Western Minnesota and Eastern North Dakota. From Report of United States Commission of Fish and Fisheries for 1893.

Carus, Dr. Paul. The Religion of Science. Chicago: The Open Court Publishing Co. Pp. 125. 50 cents.

Chester, Albert Huntington. A Dictionary of the Names of Minerals, including their History and Etymology. New York: John Wiley & Sons. London: Chapman & Hall, Limited. Pp. 320.

Comey, Arthur Messinger. A Dictionary of Chemical Solubilities (Inorganic). New York and London: Macmillan & Co. Pp. 515. $5.

Cope, E. D., Ph. D. The Primary Factors of Organic Evolution. Chicago: The Open Court Publishing Co. Pp. 547. $2.

Fisher, J. H. Hypnotism and its Relation to Witchcraft, Ghostology, and Mind Cure. Grand Rapids: Seymour & Muir Printing Co. Pp. 83.

Halleck, R. P. Psychology and Psychic Culture. New York: American Book Co. Pp. 368. $1.25.

Hart, Ernest. Hypnotism, Mesmerism, and the New Witchcraft. New and Enlarged Edition. New York: D. Appleton & Co. Pp. 212. $1.50.

James, William. Is Life worth Living? Philadelphia: S. Burns Weston. Pp. 63.

Knauff, Theodore C. A Dissatisfied Farmer. Philadelphia: The Sound Money League. Pp. 45.

Le Plongeon, Augustus, M. D. Queen Moó and the Egyptian Sphinx. New York: Author. Pp. 277.

Mosso, Angelo. Fear. Translated by E. Lough and F. Kiesow. New York and London: Longmans, Green & Co. Pp. 278.

Nye, Bill. Bill Nye's Sparks. Pp. 181.—Nye and Riley's Wit and Humor. Pp. 203. Chicago: F. Tennyson Neely.

Ribot, Th. The Psychology of Attention. Chicago: The Open Court Publishing Co. Pp. 120. 75 cents.

Romanes, George John. An Examination of Weismannism. Chicago: Open Court Publishing Co. Pp. 209. 85 cents.

Schoenhof, J. A History of Money and Prices. New York and London: G P. Putnam's Sons. Pp. 332. $1.50.

Tyndall, John. The Glaciers of the Alps. New Edition. New York and London: Longmans, Green & Co. Pp. 445. $2.50.

White, Andrew D. A History of the Warfare of Science with Theology in Christendom. Two vols. New York: D. Appleton & Co. Pp. 889. $5.

Fragments of Science.

Some New Observations on Underground Temperatures.—Some recent observations on underground temperatures are described in the December number of the American Journal of Science by Prof. A. Agassiz. He says: "For several years past I have, with the assistance of Mr. Preston C. F. West, been making rock temperature observations as we increased the depth at which the mining operations of the Calumet and Hecla Mining Company were carried on. We have now attained at our deepest point a vertical depth of 4,712 feet, and have taken temperatures of the rock at 105 feet; at the depth of the level of Lake Superior, 655 feet; at that of the level of the sea, 1,257 feet; at that of the deepest part of Lake Superior, 1,663 feet; and at four additional stations, each respectively 550, 550, 561, and 1,256 feet below the preceding one, the deepest point at which temperatures have been taken being 4,580 feet. We propose when we have reached our final depth, 4,900 feet, to take an additional rock temperature, and to then publish in full the details of our observations. In the meantime it may be interesting to give the results as they stand. The highest rock temperature obtained at the depth of 4,580 feet was 79° F.; the rock temperature at the depth of 105 feet was 59° F. Taking that as the depth unaffected by local temperature variations, we have a column of 4,475 feet of rock with a difference of temperature of 20° F., or an average increase of 1° F. for 223·7 feet. This is very different from any recorded observations, Lord Kelvin, if I am not mistaken, giving as the increase for 1° F., fifty-one feet, while the observations based on the temperature observations of the St. Gothard Tunnel gave an increase of 1° F. for sixty feet. The calculations based upon the latter observations gave an approximate thickness of the crust of the earth in one case of about twenty miles, in the other twenty-six. Taking our observations, the crust would be over eighty miles, and the thickness of the crust at the critical temperature of water would be over thirty-one miles, instead of about seven and 8·5 miles as by the other and older ratios. . . . The holes in which we placed slow registering Negretti and Zambra thermometers were drilled, slightly inclined upward, to a depth of ten feet from the face of the rock and plugged with wood and clay. In these holes the thermometers were left from one to three months. The average annual temperature of the air is 48° F.; the temperature of the air at the bottom of the shaft was 72° F." A possible source of error in these observations arises from the free access which the surface air has to the mine, and the probable effect which it must exercise on the rock temperature for many feet about it. This is, of course, also true of the previous observations, conducted in mines or tunnels. Another feature which would perhaps introduce a source of error is the close proximity of the enormous mass of water in Lake Superior. It seems probable that the rock temperature in this whole region is largely modified by the vast body of water in the lake system.

The Northern Appalachians.—A concise, satisfactory summary of the characteristics of the northern Appalachian Mountain ranges is given by Mr. Bailey Willis in a paper published in the series of Monographs of the National Geographic Society. Instead of being marked by a central crest, as is usually the case, these ranges are characterized by a central zone, the surface of which is lower than the ranges on either side. This zone is a very complex valley, or series of valleys, and is known by different names in different sections of its length of a thousand miles. Two principal ranges bound it—one on the southeast, generally known as the Blue Ridge, and the other on the northwest, known as the Alleghany Front. They extend in two nearly parallel lines about seventy-five miles apart, and have each its special characteristics. The rivers flow either to the Atlantic or to the Ohio River. The divide between these groups of streams is winding and often inconspicuous, and has no definite relation to the

principal heights. The Delaware, Susquehanna, and Potomac rise west of the Alleghany Front, which they cross, and, continuing eastward, traverse the Alleghany ridges and the Blue Ridge to reach the Atlantic. From among the Alleghany ridges of Virginia the James and Roanoke flow through the Blue Ridge eastward. New River, on the contrary, has its source east of the Blue Ridge in North Carolina, and runs northwest across the Blue Ridge, the Alleghany ridges, and the Alleghany Front, to the Ohio. It is thus a general fact that the streams of the Appalachian ranges are not controlled by the mountains. The ridges pursue their courses, and the streams, passing across the ridges, pursue independent courses. The discordance is one of the most marked features in the topography, and it gives rise to many picturesque water gaps. It is due to the fact that the transverse river channels are older than the valley ridges. Within the valley the brooks and creeks have arranged themselves usually in systems of pairs. Flowing southwest, a brook meets its fellow running northeast, and together they turn southeast or northwest to traverse a ridge. In the valley beyond the ridge they are joined by a pair similar to their own courses before their union. Beyond a second ridge or a third, the growing creek may for a time flow northeast or southwest, but it will presently pass out by another water gap. Ultimately it falls into one of the great transverse rivers. This arrangement of parallel brooks which swell the volume of a creek generally flowing at right angles to their courses, resembles a vine from whose central system branches are trained on a trellis. Although most conspicuously developed in the Alleghanies, this trellis system of drainage is common in regions where beds of hard rock lie steeply inclined to the general surface. The parallel branches of the system are controlled by the parallel ridges between each two pairs. Thus it appears that the hard rocks have to this extent influenced the arrangement of the streams.

Petroleum-Lamp Accidents.—The recent report of Mr. Alfred Spencer, an officer of the control department of the London County Council, on petroleum-lamp accidents, and the measures necessary for preventing them, is a very important and practical document. His conclusions regarding their safe construction and proper management are as follows: (1) The oil reservoir should be of strong metal, properly folded and soldered at the joint, and should not be of china, glass, or other fragile material. (2) There should be no opening between the reservoir and the burner, other than through the tube which holds the wick, and this tube should be extended to within a quarter of an inch of the bottom of the reservoir, and should have no opening into the reservoir except at its base. (3) The burner should be securely attached to the reservoir, preferably by means of a strong and well-made screw attachment. (4) There should be no openings through which oil could flow from the reservoir should the lamp upset. (5) Every table lamp should have a broad and heavy base, to which the reservoir should be strongly attached. (6) Wicks should be soft and not tightly plaited, and should quite fill the wick-tube without having to be squeezed into it. (7) Wicks should be frequently renewed, and before being put into lamps should be dried at a fire and then immediately soaked with oil. (8) The reservoir should be filled with oil before the lamp is lit. (9) The lamp should be kept thoroughly clean, all oil should be carefully wiped off, and all charred wick and dirt removed, before lighting. (10) When first lit, the wick should be partially turned down, and then gradually raised. (11) The wick should not be left turned down, as there is then a greater liability to explosion in lamps of unsafe construction. (12) Lamps which have no extinguishing apparatus should be put out as follows: The wick should be turned down until there is only a small, flickering flame, and a sharp puff of breath should then be sent across the top of the chimney, but not down it. (13) Cans or bottles used for oil should be free from water and dirt, and should be kept thoroughly closed.

The Serum Treatment of Disease.—It is stated in the British Medical Journal that the serum treatment of disease probably originated in the observation made by Von Fodor, in 1887, that blood when drawn from the body had a distinct bactericidal action. "Nuttall and others then pointed out that

although this bacteriological action might be connected with the corpuscles of the blood, it was not confined to them, as the serum of freshly coagulated blood was found to contain some proteid substance which undoubtedly exerted a powerful bactericidal effect. In July, 1889, Babes and Lepp recorded a number of experiments in which they had found that the blood of dogs which had been vaccinated against rabies exerted a distinctly protective action when injected into susceptible animals, either previous to or along with the virus procured from a rabid animal. Ferran appears to have been the next observer to accentuate this point. He was followed by Bouchard in France, while Behring and Kitasato in Germany, and then Roux in Paris, and others in rapid succession pointed out that there was in the serum of the blood of animals vaccinated against diphtheria and tetanus a distinct prophylactic and curative agent which, however, it was difficult to separate from the serum. In 1891 patients were treated in Berlin with a serum prepared by Behring, and since then this serum has been prepared and used in nearly all civilized countries."

Infected Drinking Water.—There is a growing tendency among physicians to belittle the purely chemical examination of potable water, and to rely solely upon the results of the bacteriological tests. A recent episode, the result of which seems at first sight to strengthen this view, occurred during the trials undertaken by the London Local Government Board, in which water samples, purposely inoculated with typhoid germs, were sent for analysis to one of England's leading chemists, and were by him pronounced pure. The obviously weak point in drawing such a conclusion from the above occurrence lies in the fact that such a sample of water would not be found in practice. The mere fact that it contained no sewage, to detect which is the chief purpose of the chemical analysis, would almost certainly in practice preclude the typhoid bacillus, the pure culture being only a laboratory product. The same is practically true with all the pathogenic micro-organisms which are liable to occur in drinking water. The chemical ingredients which the sewage supplies are quite essential for the rapid growth and multiplication of the bacteria. In fact, a favorable breeding ground is perhaps not second in importance to the presence of the germ itself, as the number of individual microbes, up to a certain point, which gain access to the human body, is probably of much more importance than the kind of germ. "The chemist," says Prof. W. P. Mason, in an article in the Journal of the American Chemical Society, "is unable to say whether or not a sewage-laden water is disease-bearing on any particular date, for to him all sewage is alike, but he condemns the water for the reason that, although it may be harmless to-day, it is impossible to predict what may be its condition to-morrow. Within the week I have been requested to make a bacteriological examination of the water of a certain well, in order to determine if it be affected by neighboring cesspools. The physician who made the request was impressed with the belief in the paramount value of such an examination and the comparative uselessness of chemical analysis. I am quite convinced that, had I followed his suggestions, I should have sought in vain for any specific microbe, but inasmuch as, upon chemical analysis, I found that the chlorine ran twenty-four parts per million, which is about ten times the local 'normal,' and the 'nitric nitrogen' read nine parts per million in place of 0·116, I condemned the water offhand without going further. . . . As Dr. Dupré has pointed out, chemistry in such cases anticipates what may happen in the future, and by timely advice may prevent an outbreak of disease; while, on the other hand, the discovery of disease germs in a water is only possible after the water has become infected."

A New Low-Temperature Apparatus.—A most interesting and important demonstration of the efficiency of the process of self-intensification of cold produced by expansion alone without the aid of any extraneous artificial refrigeration is described in a recent issue of Nature. The apparatus consisted of three coils of narrow copper tubing arranged concentrically in a metal case, and connected successively together. The gas, say oxygen, enters the outer coil at a pressure of one hundred and twenty atmospheres, passing from this into the second, and from

this into the central coil, which is surrounded by a cylindrical glass vacuum-jacketed vessel as devised by Prof. Dewar. The two outer coils are separated from each other by vertical divisions of the case, and the spiral of the central coil is followed by a flat spiral of sheet copper. When the gas reaches the extremity of the central coil, it escapes through a fine orifice of peculiar construction, formed by bringing two knife edges closely together. The size of the orifice can be regulated by means of an ebonite rod, which passes up the axis of the apparatus, and terminates in a handle at the top. After its escape the whole of the gas cooled by expansion passes through the spaces surrounding the pipe in which the compressed gas is passing to the point of expansion, and so makes this gas, still under pressure, cooler than it was itself while under compression. The compressed gas consequently becomes, at the point of expansion, cooler than that which preceded it, and in its turn follows backward the course of the still compressed gas, and so makes the latter cooler than before expansion, and also cooler than ever after expansion. This intensification of cooling (always assuming sufficient protection against access of heat from the outside) is only limited by the liquefaction of the gas, the temperature of liquefaction being in the case of oxygen 180° C. The apparatus exhibited measures twenty-eight inches deep by seven inches in diameter, and when once cooled down—that is, in about half an hour—it yields liquid oxygen at the rate of about seven cubic centimetres in four minutes.

How Opium is Prepared.—The English consul at Ispahan gives the following description of the process: The people commence to collect the drug early in May. The poppy head is lanced in the afternoon, and the opium which exudes and dries during the night is collected into copper pots early the following morning. It is kept in store in these pots until required for exportation. Then it is taken out of the pots and sorted. For the succeeding manipulations, each workman has a smooth board, about twenty-three inches long and eleven inches broad. He takes from the bulk about one pound of the crude opium, and rubs it on the board for a short time, then puts it in the sun for ten minutes, and afterward takes it into the shade and rubs it continuously with an iron implement something like a small solid spade, until it dries up to a certain degree. It is then collected into a mass and heated in trays over a small charcoal fire until plastic. Each man then takes about a quarter of a pound, and kneads it again on the board until it dries up to the standard degree and assumes a golden yellow color. It is next made up into cakes of one pound each, which are wrapped up in paper and placed in tin boxes, in layers alternating with poppy chaff. These tin boxes are packed in wooden ones covered with hide and gunny, and the opium is then ready for exportation.

The Finger-print Method of Identification.—In a recent letter to Nature, Kumagusu Minakata gives some interesting data, which seem to indicate that the ancient Japanese use of finger marks on divorce papers, as a means of identification, which the author described several years ago in the same periodical, was probably adopted from the Chinese Laws of Yung-Hwui, somewhere about 650 A. D. He has found a passage in the Arabian Relation des Voyages by one Sulaiman, who made several voyages to China and India in the middle of the ninth century A. D. (the time in which the above-mentioned dynasty in China was going to decline), describing the Chinese method of drawing up a contract: "The Chinese respect justice in their transactions and in judicial acts. If a man lends a sum of money to some one, he puts it down in writing. The borrower, in his turn, makes a similar writing, which he marks with two of his fingers together, the index and the middle finger. The two papers are put together and folded. Some characters are written across the portion where they join. They are then unfolded, and the writing by which the borrower acknowledges his debt is given to the lender. If, at a later time, the borrower denies his debt, he is told to bring the writing of the lender. If he pretends not to have it, and says he has never written a paper accompanied by his signature and his mark, and that his writing has been destroyed, they say to the borrower who denies his debt: 'Declare in writing that that debt

does not concern you. But if the creditor proves that which you deny, you will receive twenty blows on the back, and will pay an amend of twenty thousand (*fakoudj*) pieces of copper.'" The antiquity of this custom is of especial interest just at present, because of the rise into prominence of the so-called Bertillon system of identifying criminals, which is based on the finger-print method.

Solid Air.—In a recent address on The Liquefaction of Air and Research at Low Temperatures, before the Chemical Society, Prof. J. Dewar gave some very interesting descriptions of such unusual substances as "solid air" and "liquid hydrogen." He says: "If a litre of liquid air be exhausted in a silvered vacuum vessel, half a litre of solid air may be obtained and kept solid for half an hour. The solid is at first a stiff, transparent jelly, which, when placed in a magnetic field, has the still liquid oxygen drawn out to the poles, showing that solid air is a nitrogen jelly containing liquid oxygen; solid air can only be examined in a vacuum, or an atmosphere of hydrogen, because it instantly melts on exposure to the air, causing an additional quantity of air to liquefy. It is strange to see a mass of solid air melting in contact with the atmosphere, and all the time swelling up like a fountain. . . . A small ignited jet of hydrogen burns continuously below the surface of liquid oxygen, all the water produced being carried away as snow. . . . By means of a jet of liquid hydrogen, liquid air and oxygen were transformed into hard white solids resembling avalanche snow, quite different in appearance from the jellylike mass of solid air got by the use of the air pump." The only widely distributed element which has not yet been liquefied is fluorine.

Curious Verbal Customs in Madagascar.—A curious custom—said to be common throughout the country—of changing names and words, is described in J. T. Last's Notes on the Languages Spoken in Madagascar. The mention of the name borne by the king while living is tabooed after his decease, and violation of this law may be punished even with death. The name of a chief is tabooed to all in any way connected with him, and that of a notable person to all belonging to his family; and should there be another person in the family bearing the same name as that of the person deceased, that name must be laid aside and another one taken. This change of name is often made as a mark of respect for a friend. It is considered an honor to the dead man to change one's name. The author while traveling once heard some guns fired off in the distance-denoting death. He found, on inquiry, that the deceased was a grown-up daughter of a certain person; but the people were careful not to mention her name, because it was to be changed, and they did not yet know what new name would be adopted for her. The names given to deceased kings and chiefs are invariably formed of three words, of which the first is always *Andriana*—lord; the second some word denoting respect or honor, or pointing to some characteristic of the deceased; and the third and last, *arivo*—a thousand. Even among the common people it is considered highly indecorous to mention the name of a deceased person. Some special words are the exclusive property of kings and queens. Besides these, a number of words are common to kings and chiefs, but can not be used in the same manner by the other people. Again, the king has power to make certain words "fady," that is, to prohibit their use either for a time or entirely; and then other words must be adopted to be used in their place. Changes are often made in the use of words by the prohibition of words containing part of the name of the king or queen. These customs may be made to account for some of the differences existing between neighboring dialects; and their value as factors may be estimated when we consider the number of petty kings in Madagascar, and remember that the rules as to the name of each produce more or less permanent changes in the language.

The Deepest Sounding yet made.—It is stated that Captain Balfour, of H. M. S. Penguin, has obtained three soundings of over five thousand fathoms. They were taken in the Pacific Ocean at the following points: Latitude south, 23° 39°; longitude west, 175° 4′, 5,022 fathoms, at which point the wire broke; latitude south, 28° 44′; longitude west, 176° 4′, 5,147 fathoms; and

latitude south, 30° 28′; longitude west, 176° 39′, 5,155 fathoms (30,930 feet). The usual abysmal red clay was brought up by the sounding tube on the two latter occasions. Mr. V. Thorpe, surgeon of the Penguin, reports a microscopic examination of the specimen from 5,147 fathoms, which shows that the remains of siliceous organisms are almost if not entirely absent. The mineral particles are in a minute state of disintegration, and consist of exceedingly fine flocculent matter, mixed with pumice and other glassy volcanic products, green crystals of augite, and reddish crystals of pelagonite. The deepest trustworthy sounding previously made was 4,655 fathoms, obtained by U. S. S. Tuscarora near Japan in 1874.

Scientific Acquisitions from the Peary Expedition.—While adverse circumstances made it impossible for Lieutenant Peary to carry out, in full, his plans with reference to the northwest coast of Greenland, he, nevertheless, as Mr. Rollin D. Salisbury has shown in Science, accomplished much during his arctic residence. He twice crossed the ice cap from Inglefield Gulf to Independence Bay, and gathered information of singular value concerning the inland ice and the ice-free territory beyond. He mapped a considerable stretch of the coast from Cape Alexander to Cape York, or from latitude 78° 10′ to 75° 55′, covering eight degrees of longitude, and with indentations, prominences, and islands one thousand miles in length. This map includes so many features not given in the other maps that it is hard, at first sight, to recognize the identity of the regions. Eleven before unknown islands were accurately located, and the position, shape, and size of those heretofore represented were corrected. Possibly a hundred glaciers were located with approximate accuracy within a region where only ten were represented—not always correctly—on the published chart. Astrup's map of Melville Bay was prepared while its author was a member of Lieutenant Peary's company. A series of accurate and elaborate meteorological records was kept up, in which, besides the formal entries, observations were noted of the behavior of the winds about the ice sheet, presenting facts which may be of use in the study of the problems of glacierology. Measurements were made of the rate of motion of one of the most active glaciers of the region, and continued so long as to render them of special value. Two large meteorites were brought back for study. Lieutenant Peary enjoyed rare opportunities of personal contact and association, by living with them, for studying the Eskimos of north Greenland, and intends to publish the results of his studies. Much has been gained, further, through the expeditions which Lieutenant Peary caused to be sent into northern waters. Prof. L. L. Dyche, who joined the party in Greenland, secured valuable zoölogical collections of birds, walruses, reindeer, seals, and narwhals. Mr. Salisbury made observations and studies of the geographical and geological features of the west coast of Greenland, between latitudes 69° and 78° 45′, at close range from the vessel, and at numerous stopping places. Many glaciers were studied in detail, determinations respecting glacier motion were made, evidence was gathered touching the former extension of the ice cap of Greenland, and determinations were made concerning recent changes of level in the land.

Micronesia.—The following description is taken from a paper on the Marshall Islands, read before the Berlin Geographical Society on June 8, 1895: "The Marshall group consists of two nearly parallel series of islands, running from north-northwest to south-southeast, which are named by the natives *Ratak* (Islands toward the Dawn) and *Relik* (Islands toward the Sunset). The group covers about one hundred and seventy-six square miles. All are coral islands and most of them atolls. Of the *Relik* group the most important are Yaluit (the seat of government), Ebon, and Namvik. Of the *Ratak* group, Mejem has a population of about twelve hundred. The climate is, for a tropical region, comparatively favorable to Europeans. There are no swamps, but the continued high temperature and the moisture of the air render them dangerous for Europeans with heart or lung disease. Besides affections of the heart and kidneys, dysentery and rheumatism (both of the muscles and joints) are not uncommon. Observations extending over three years gave the mean temperature as 80·6° F., the extremes being 93° and 71°. The rainfall is

pretty evenly distributed throughout the year, and is quite excessive (one hundred and seventy-seven inches). It is only in January and February that a comparatively dry period can be expected. The northeast trades blow from December to April, becoming rather easterly or southeasterly from March to November. Calms or violent southwesterly storms occur chiefly between August and November. There being no springs, a supply of water is collected in tanks or cisterns. The useful plants include the cocoanut palm, breadfruit tree, and *Pandanus odoratissimus*, the sap of which last is rich in sugar. The cultivation of plantains has much increased of late, besides which several kinds of arums, the South Sea arrowroot (*Tacca pinnatifida*), and a mangrove which supplies a black dye are grown. Guavas, figs, citrons, and anonas thrive well, but tea, coffee, cacao. etc., can not be grown at all. The Micronesian population amounts to from twelve thousand to thirteen thousand. The population belongs to four sharply defined classes. The great mass consists of the common people (*Kayur*); the next higher class is that of the *Leatakketak*, comparable to village magistrates, who see that the orders of the chiefs are carried out. Neither of these classes own land, but they are allowed to grow as much produce or catch as much fish as is necessary for their sustenance. The ordinary chiefs (*Burak*) rank above both these classes, and they often possess larger holdings than the head chiefs (*Iroj*). All the members of these four classes acquire their rank through the mother only. The race seems to be deteriorating physically, owing to the prevalence of specific disease, with which about fifty per cent of the inhabitants are afflicted."

MINOR PARAGRAPHS.

Anianus Jedlik died on the 12th of last December, at the cloister of the Benedictine order, in Gyor. He belonged to the old order of natural philosophers (he was born in 1800) who lacked that important portion of the latter-day physicists equipment, a knowledge of higher mathematics. Some of his more important treatises were under the following titles: The Deflection of Beams (1845); The Application of the Electro-magnet in Electro-dynamic Rotations (1856); A Modification of Grove and Bunsen's Battery (1857); The Magneto-motor (1857); Concatenation of Leyden Jars (1863); Electro-magnetic Undulation Machine (1868).

M. Abel Hovelacque, one of the most industrious and successful of the younger French students of anthropology, died in Paris, on the 22d of February, aged fifty-two years. His effective scientific career began in 1867, when, at the age of twenty-three years, he founded, with Chavée, the *Revue linguistique*, the first journal in France specially devoted to linguistics; joined the Anthropological Society, and began the publication of articles in various periodicals. These articles, largely relating to linguistic and cranial investigations, were followed by books on Our Ancestor; The Beginnings of Mankind; a Grammar of the Zend Language; an Elementary Linguistics; Languages, Races, and Nationalities; Observations on Herodotus and the Persians; The South Slavs; Linguistics; The Avesta, Zoroaster, and Mazdeism; and a lecture on the Evolution of Languages. On the foundation, by Broca, of the École d'Anthropologie, in 1876, Hovelacque was made Professor of Linguistic Ethnology. In 1890 he was made president of the school and chief director of the *Revue mensuelle de l'École d'Anthropologie*. He has also taken part with other anthropologists, whom M. André Lefevre speaks of collectively as a group, in other important enterprises and publications in anthropology.

La Revue Scientifique of December 14th contains an interesting anthropological note. It had been noticed that the wounds made by the arrows of the natives of New Hebrides were quite regularly followed by tetanus, and that the surrounding inhabitants were more afraid of these arrows than of a rifle bullet. A commission at Melbourne experimented on some animals, with these arrow points, in order to discover their poison, but obtained no results. So far as the animals were concerned, the arrows were not poisoned. A somewhat similar commission in 1883, authorized by the Governor of New Caledonia, gave no better results. In

preparing these arrows, the natives first cover the points with a mucilaginous compound, and then plunge them into the soil of crab burrows in some neighboring swamp. Hence it seems probable that years before our isolation of this virulent germ these savages were utilizing its fatal properties in their warfare.

NOTES.

OBSERVATIONS have been made by Prof. Lloyd Morgan on instinct in young birds with a view to determine how far the activities involved in swimming, diving, running, flying, feeding, bathing, etc., are instinctive or congenital, and how far the definiteness of this and other activities is a matter of individual acquisition. Other observations were on congenital and acquired timidity. They indicated that while the performance of the activities in question has a congenital basis, they are perfected by individual acquisition, and that there is no instinctive avoidance of insects with warning colors, this seeming to be entirely the result of individual experience. No material support was afforded to the view that the instinctive activities result from the inheritance of what is individually acquired.

UNDER the law of the State of New York the duty of analyzing artificial fertilizers and of prosecuting manufacturers of fraudulent goods is committed to the Agricultural Experiment Station at Geneva. Since May, 1894, prosecutions have been instituted in the case of eleven brands which fell materially below the guaranteed analyses. More than two thousand samples of commercial fertilizers have been collected and analyzed since July, 1890; and since October, 1890, thirteen fertilizer bulletins have been published, containing four hundred and twenty pages, of each of which about fifteen thousand copies have been distributed among the farmers of the State. The station has the addresses of one hundred and twenty firms doing business in fertilizers in this State, the goods of fifty-three of which are manufactured in other States. Its publications are sent free to all farmers in the State who ask for them.

THE knowledge of sugar has been traced back away into the darkness of the past. The Chinese have been acquainted with it, according to the *Fortschritte der Industrie*, for more than three thousand years. From Asia, where it was extracted from a cane, it was brought into Greece by one of the generals of Alexander the Great, B. C. 325. In A. D. 150 it was prescribed by the doctor Galenus as a remedy for certain diseases. The refining of sugar was practiced in England about 1659. The story runs that the secret of sugar making was brought to Sicily by a Venetian merchant, who bought it from the Arabs for a hundred thousand crowns.

THE number of metals found to be capable of combining with argon at a red heat is gradually increasing, and now includes magnesium, lithium, barium, aluminum, zinc, iron, and copper. Metallic barium has been found to absorb nitrogen rapidly, and its use as a cheap means of preparing argon from air has been suggested. Lithium absorbs nitrogen with incandescence at temperatures below a red heat; and it has been shown by M. Deslandres and M. Guntz that this absorption takes place slowly in the cold.

AMONG the scientific works announced for publication by Henry Holt & Co. are a book on Electricity, by Prof. Charles A. Perkins, of the University of Tennessee; A Problem Book in Elementary Chemistry, by E. Dana Pierce, of the Hotchkiss School, Lakeville, Conn., and the amusing *Preisgekrönt* of Eckstein, edited by Prof. Charles Bundy Wilson, of the University of Iowa, will shortly be added to the series of German texts published by this house.

IN its issue for May 9th the Scientific American gives the particulars concerning an offer of a prize of two hundred and fifty dollars, which it makes for the best essay on The Progress of Invention during the Past Fifty Years received by June 20th. The prize essay will be published in the special fiftieth anniversary number of that journal on July 25th, and regular rates of compensation are offered for the five next best essays.

THE institution of Arbor Day was started in Nebraska, in 1872, by the Hon. J. Sterling Morton, our present Secretary of Agriculture. The first efforts, as its history is told by Mr. B. O. Northrop, were not assuring; but its progress has been remarkable. The day is now observed in forty States and Territories of the United States, in Canada, and in certain districts of England, Australia, Japan, and South Africa. The Western settler who does not now plant trees is an exception; and the people of Nebraska, in particular, are proud of what they have achieved in this work.

THE death-rate in the German army, which was 6·9 per thousand in 1870, was in 1894 only 2·4 per thousand. This decrease during the past twenty-five years in the death-rate in standing armies has been very general, and is accounted for by improved hygiene and sanitation. During the Franco-German War the French lost twenty-three thousand four hundred men from smallpox. The Germans, who had been strict vaccinators for thirty years, lost only three hundred men from this disease. The strictness of the vaccination law in the latter army may be gathered from the fact that since 1873 only two soldiers in this immense collection of men have died of smallpox.